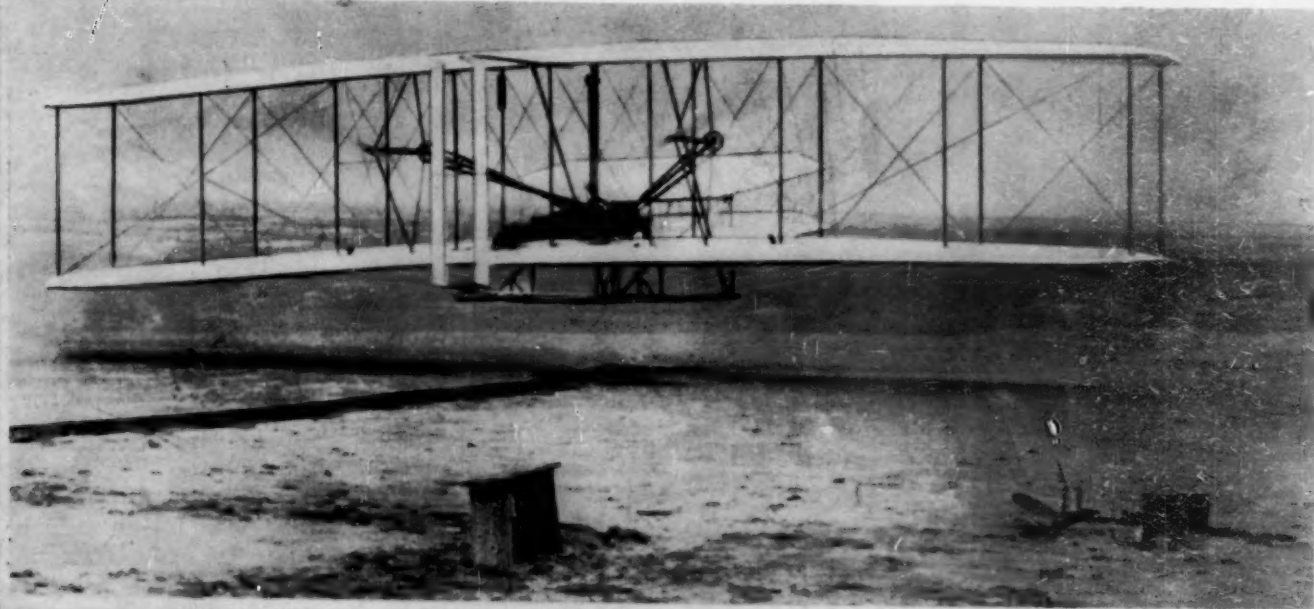


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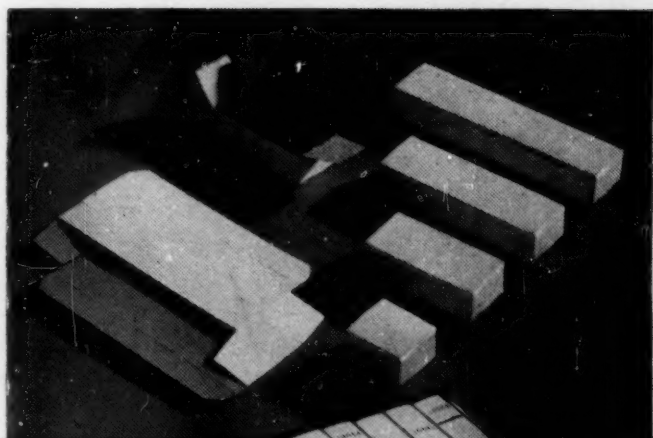
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Science

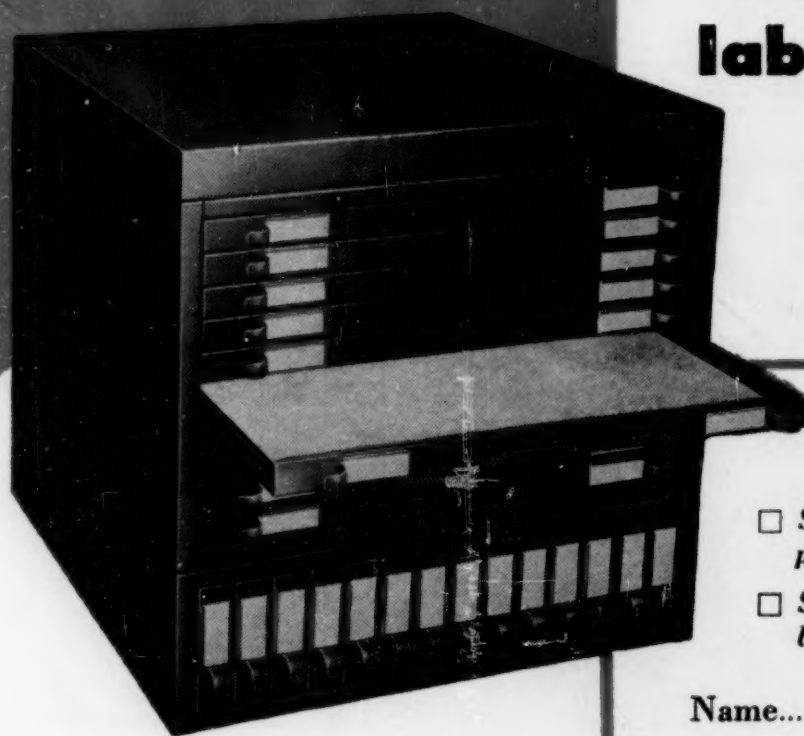


Kitty Hawk, 1903—Clipper, 1948

(See page 733)



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A Proposed Provisional Definition of Poliomyelitis Virus

Committee on Nomenclature of the National Foundation for Infantile Paralysis¹

SOME CONFUSION EXISTS AT PRESENT as to what restriction should be applied to the use of the term *poliomyelitis virus* as opposed to the allied terms *encephalomyelitis* or *encephalitis virus*. Furthermore, there are differences of opinion regarding the status of so-called murine poliomyelitis viruses and their suitability as models in poliomyelitis research. Thus, there seems to be a need for clarification regarding questions of nomenclature, and already several attempts have been made to achieve this end.²

The object of these proposals is to define the limits of the use of the term *poliomyelitis virus*. There is little doubt that a group or family of poliomyelitis viruses exists. The question at issue is: What neurotropic strains should be admitted to this family group? Probably a true classification would be inadequate at this time, but until such time as proper means are available for designating individual members of this family, as Poliomyelitis Virus A, B, or C, etc., the following plan is proposed as a temporary substitute.³

These proposals are not presented as authoritative or official, or as a set of standards which should

necessarily supersede the recommendations of any official scientific bodies which have previously been concerned with these matters. They are presented, rather, as an expression of opinion of this particular Committee at this particular time.

I. POLIOMYELITIS VIRUSES

Diagnostic criteria. The term *poliomyelitis virus* should be used to designate strains of the agent originally described as the cause of poliomyelitis in man, regardless of the source from which it may be recovered in nature. Viruses isolated from the spinal cord of fatal cases of human poliomyelitis or the throat washings or feces from typical cases occurring in characteristic seasonal outbreaks may be tentatively presumed to be poliomyelitis viruses. Their exact identification, however, must be based, first, upon *clinical and histopathological* manifestations of the disease produced in monkeys; second, upon *host range*; third, upon *immunological relationships*; and finally, upon *physicochemical properties of the virus*.

(a) *The experimental disease in monkeys.* The monkey is the preferred host for diagnostic studies of newly isolated strains, since those regions of the primate brain which characteristically are free of lesions in poliomyelitis are poorly developed or absent in lower mammals. The use of the monkey, therefore, eliminates an important difficulty which occurs in differentiating poliomyelitis from other neurotropic diseases—in rodents, for example—on the basis of distribution of cerebral lesions.

(i) *"Clinical" signs.* Monkeys in which experimental poliomyelitis is produced usually manifest certain characteristic "clinical" signs after a variable incubation period (4–20 days in over 90% of cases). Fever, tremor, and spasticity of muscles, usually followed by paralysis within a day or two, are common signs. Other findings are similar to those observed in human poliomyelitis. The occurrence of severe generalized tremors, accompanied by definite flaccid paralysis, is almost without exception pathognomonic of poliomyelitis in the monkey. Cranial nerve paralyses occur, but are less common; paralysis of tail musculature is so rare as to lead to the suspicion of a spinal lesion due to some other cause. *All of the aforementioned signs may be absent or escape detection*, but the diagnosis can, nevertheless, be made by means of histopathological findings.

¹Members of the Committee are: C. Armstrong, D. Bodian, T. Francis, Jr., A. B. Sabin, and J. R. Paul.

This outline was discussed at a meeting held on July 14, 1948, during the First International Conference on Poliomyelitis held in New York City. Besides the members of the above-mentioned Committee the following were present: R. Thompson, S. O. Levinson, A. J. Shaughnessy, H. A. Howe, J. H. S. Gear, G. Dalldorf, L. Aycock, P. R. Lépine, I. M. Morgan, R. Ward, C. W. Jungeblut, J. L. Melnick, S. Gard, T. M. Rivers, H. M. Weaver, and T. E. Boyd. At this meeting the four items in the *Summary and Recommendations* of the outline were submitted to vote and were all passed unanimously.

²This matter was considered at the Fourth International Congress for Microbiology held in July 1947 in Copenhagen, Denmark. It was further discussed at a Conference on Immunologic Types of Poliomyelitis Virus sponsored by the National Foundation for Infantile Paralysis and held in Washington, D. C., January 8, 1948, at which time the above-mentioned *ad hoc* Committee on Nomenclature was formed.

³An attempt has recently been made to classify the viruses of the "poliomyelitis groups" in the 1948 edition of Bergey's *Manual of determinative bacteriology* (2). Under one genus (*Legio*), the classification includes: human poliomyelitis virus, lymphocytic choriomeningitis virus, pseudolymphocytic choriomeningitis, Theiler's mouse encephalomyelitis virus, avian encephalomyelitis virus, and swineherd's disease virus. Under human poliomyelitis virus the experimental hosts listed include monkey, and for some isolates, cotton rat, mouse, guinea pig, and white rat. We do not believe that this classification is sufficiently critical or adequate.

(ii) *Histopathological findings.* The histopathological lesions of poliomyelitis in the brain and in the spinal cord are so highly characteristic in nature and distribution that it is important to confirm clinical findings with pathological study. The lesions essentially duplicate those of human poliomyelitis, in type and in distribution. In the spinal cord, lesions are concentrated in the gray matter, and primarily in the anterior horns. *Signs of damage to motor nerve cells must be present* in the acute stage (severe diffuse chromatolysis, neuronal necrosis, neuronophagia, and "outfall" of cells). In addition, focal and diffuse infiltration of leucocytes in areas of nerve cell damage, and perivascular "cuffing," always accompany these signs of nerve cell damage or destruction.

An important differential point is the pattern of distribution of cerebral lesions. The brain-stem contains lesions in every case, but lesions may be variable in severity. The cerebral cortex is generally spared except for the precentral gyrus. The cerebellar hemispheres are generally spared, except for the vermis, but the deep cerebellar nuclei are usually involved, especially the roof nuclei. The basis pontis and inferior olives contain lesions only infrequently and are never severely involved.

(b) *Host range.* Primates are the only known experimental hosts for most strains isolated directly from human or extrahuman sources. Any virus which produces the characteristic experimental disease in monkeys, but does not infect other mammals, may be considered as poliomyelitis virus. Certain strains (Lansing, MEF₁, Y-SK, and Ph) isolated from typical human cases have the additional capacity of producing paralytic poliomyelitis in mice, hamsters, and cotton rats but not in guinea pigs or rabbits. These strains, so far as is known, are immunologically closely related to the Lansing-1938 strain. Any new virus which is atypical with respect to host range should be classified only after complete consideration of its other properties.

(c) *Immunological diagnosis.* Any virus which is immunologically distinct from any previously established poliomyelitis virus but which possesses the above-mentioned diagnostic properties must, nevertheless, be considered as a poliomyelitis virus. Any virus that is immunologically identical to a previously established poliomyelitis strain may be tentatively considered as a poliomyelitis virus.

(d) *Physicochemical properties.* These properties are useful adjuncts in diagnosis. Too few details are known, however, for them to be considered as distinguishing qualities.

(i) *Size of virus.* An important property in identifying poliomyelitis virus is its small particle size.

Results of ultrafiltration studies yield an estimated diameter in the range of 8-12 mμ. Electron microscopy studies have not yet clearly established the size and shape of the virus.

(ii) *Resistance to ether* is a striking but not specific characteristic. It may serve as an additional differential point between poliomyelitis and certain other neurotropic viruses.

Special Strains of Poliomyelitis Virus

The evidence that there are multiple types of poliomyelitis virus is strong, as determined by immunity tests. Examples of these are numerous and will not be particularized here.

One type, of which the Lansing virus is the original and classical example, perhaps deserves special mention. This virus, originally isolated (1938) from a human case (1), meets the criteria of a poliomyelitis virus as listed in paragraphs I (a-d) and in addition is infective for cotton rats, white mice, and hamsters. Also, from these rodents it was found capable of re-infecting monkeys—its immunological characteristics being maintained. This strain, moreover, is neutralized by human sera from many localities.

Several other strains (MEF₁, Y-SK, and Ph) generally as well as antigenically similar to the Lansing strain of virus have been isolated from various parts of the world. These strains, therefore, constitute an immunological group of viruses which is considered coordinate for classification purposes with other groups of poliomyelitis virus immunologically similar to each other and antigenically distinct from the Lansing group.

Special designation of poliomyelitis strains. Under special circumstances it might be helpful if strains of poliomyelitis were, for the present, labeled by the year and the locale where obtained. In addition, the number of passages in monkeys should be indicated. Thus, the Smith-Hartford-1942-M₅ strain indicates that the strain was isolated from material collected in 1942 from patient Smith in Hartford and had been through 5 transfers in monkeys. If the strain is derived from an extrahuman source, this should also be included as, for example, Chicago flies-1943-M₂. If the above special designation of strains were used, the need for the qualifying adjectives of human or

⁴The number of passages of the virus in each host could be indicated. Thus, Y-SK-New Haven-1937-M₂₂CR₁₀m₁₀ indicates that the Y-SK strain in question was isolated from a sample collected in 1937 in New Haven and was then taken through 22 passages in monkeys; the 22nd generation of the virus in monkeys was passed to cotton rats and 5 serial passages carried out, following which it has had 10 serial passages in mice. The symbols, M, CR, and m refer to the following host species: *Macaca mulatta*, *Sigmodon hispidus*, and *Mus musculus*, respectively. If species other than these are used, their symbols should be described with a footnote giving the appropriate scientific name of the species.

monkey- or murine-adapted would be unnecessary. In fact the designation of strains as human poliomyelitis virus, monkey-adapted poliomyelitis virus and murine-adapted poliomyelitis virus is unnecessary, undesirable, and confusing.

II. OTHER NEUROTROPIC VIRUSES

It has been suggested that there exist in nature viruses which, except for the fact that they have not been shown to produce poliomyelitis in man and have a somewhat different host range from the human poliomyelitis viruses, possess similar physical properties and produce a poliomyelitis-like disease in lower animals under natural conditions, and that in a broader genetic classification these viruses should be included with the poliomyelitis group. The virus responsible for the indigenous paralytic disease of mice (Theiler's TO) and the virus of "Teschen's" disease of swine, about which relatively little is known, have been proposed for inclusion in such a classification. Although it would appear that among the various neuronotropic viruses, all of which, including the poliomyelitis group, are in one sense encephalomyelitis viruses, the Theiler "TO" virus most closely corresponds to the poliomyelitis group as regards its affinities for various tissues and nerve centers, this Committee believes the time is not ripe for setting up a broad genetic group of animal poliomyelitis viruses.

(a) *Murine neuronotropic viruses.* In this group are included viruses which are known to be of murine origin, as well as others, whose natural habitat is still obscure but which were originally recovered from mice, cotton rats, or hamsters inoculated with various materials. These form a heterogeneous group as regards pathogenicity, host range, and immunologic relationship, although the size of those "measured" thus far is of the same general magnitude as that of human poliomyelitis virus. Most of the viruses in this group can produce paralysis in mice and in recent years have frequently been designated as "mouse poliomyelitis" (in the case of those whose natural habitat is regarded as the mouse, e.g. TO, FA, GD VII), "poliomyelitis-like," or simply as "poliomyelitis," particularly when the original inoculum was derived from a patient with poliomyelitis or from a known human strain of poliomyelitis virus, e.g. Columbia SK, MM. None of these viruses fulfills the criteria set forth in the preceding section for the poliomyelitis group of viruses which includes those strains that infect rodents, such as the Lansing, MEF₁, Y-SK, and Ph. These murine neurotropic viruses have often been chosen for experimental work on poliomyelitis and have been a serious source of confusion and error in work with poliomyelitis viruses in rodents. In the opinion of this Committee, the

classification of these viruses as poliomyelitis viruses is not warranted.

It is, furthermore, proposed that the term "mouse poliomyelitis" be discontinued and that to some of these strains (e.g. TO, FA, GD VII) so designated in the past the term originally used by their discoverer, Dr. Max Theiler, be applied, namely, *spontaneous mouse encephalomyelitis* (10). Some properties of this group of viruses and the ways in which they differ from the poliomyelitis viruses are as follows:

(i) *TO.* This virus has been recovered under natural conditions from the feces of most stocks of mice and from the spinal cord and brain of mice with paralysis of the extremities. Experimentally, after intracerebral inoculation, as well as in the indigenous disease of mice, it produces paralysis predominantly of the posterior extremities, which is associated with lesions in the anterior horn cells of the spinal cord and brain stem and to a lesser extent of the cerebral cortex. Its size (8-12 mμ) is the same as that of poliomyelitis virus. Only some strains are pathogenic for cotton rats. It differs from the poliomyelitis viruses in that (1) no strain has been found pathogenic for monkeys; (2) it can be propagated in chick embryos; and (3) it is not neutralized by "normal" adult human sera which neutralize the Lansing and other strains of poliomyelitis virus.

(ii) *FA and GD VII.* These strains have not been found in the intestinal contents of mice, but were recovered from the nervous system of mice during the course of work with other viruses. They also differ from the TO strain in (1) their ability to give rise to encephalitic signs as well as paralysis and to extensive lesions in the cerebral cortex as well as in the spinal cord and brain stem; (2) shorter incubation period, high titer achieved in the nervous tissue, greater invasiveness by peripheral routes such as the intraperitoneal; and (3) capacity to perform serological tests (both complement fixation and neutralization) with them. Except in tests in which interference might have affected the cross-immunity pattern, there is no evidence of immunological relationship between these viruses and the TO strain. Unpublished data available in several laboratories suggest that viruses, with properties similar to those of FA and GD VII but immunologically unrelated to them, have been encountered in mice. The FA-GD VII group is pathogenic for cotton rats and is easily propagated in the chick embryo. The differences from the poliomyelitis group listed for the TO virus also apply to the FA-GD VII group.

The strains of virus designated as WP, NY 65, NY Pool II, and CC which were recovered from mice by Jungeblut and Dalldorf would appear to belong to the spontaneous mouse encephalomyelitis group.

(b) *Other viruses producing paralysis in rodents which have been called poliomyelitis or poliomyelitis-like.* In this group are included viruses which are immunologically different from the TO-FA-GD VII group and have a somewhat broader host range, which may include guinea pigs, albino rats, and monkeys,

although the disease produced in the latter is encephalitic. The natural habitat of this group is still obscure, although the circumstances under which they have been recovered suggest that rats and hamsters may constitute at least one source. The properties of some of these viruses and the chief ways in which they differ from those in the human poliomyelitis group are as follows:

(i) *Columbia SK*. Jungeblut and Sanders, passaging the SK strain of poliomyelitis virus (now known as Y-SK) in cotton rats, recovered a virus which has proved to be pathogenic for cotton rats, mice, guinea pigs, albino rats, and, in the later passages, also gave rise to encephalitic disease in monkeys. In mice this strain of virus yields titers of 10^{-7} or more and is highly pathogenic by the intracerebral, intranasal, intraperitoneal, intravenous, and other peripheral routes including feeding. It has been propagated in the chick embryo. Most of the present available evidence indicates that this strain is immunologically different from the original SK virus, maintained by passage in monkeys (5), and, unlike the original virus, is not neutralized by pooled adult human serum possessing antibodies for poliomyelitis virus. On the other hand, the original Y-SK strain, which has also been propagated in cotton rats and mice, behaves like the Lansing strain of poliomyelitis virus, has retained its immunologic identity with the original virus as passaged in monkeys, and does not possess the properties exhibited by the "Columbia SK" virus (6).

(ii) *MM virus*. This was recovered by Jungeblut and Dalldorf (4) from the brain of a hamster which died 19 days after inoculation with material from the medulla and cord of a patient with poliomyelitis. Although the original human material was not pathogenic for cotton rats, mice, or guinea pigs, the virus recovered from the brain of the dead hamster was found to be highly pathogenic for hamsters and for mice, cotton rats, and guinea pigs, but not for monkeys or rabbits. In mice this virus reaches intracerebral titers of 1×10^{-11} (for the 0.03-cc dose) and intraperitoneal titers of 1×10^{-9} . It is also highly invasive by other routes, including feeding, in mice and other rodents, particularly in younger animals. Both intracerebral and peripheral inoculations produce paralysis which is associated with lesions in the anterior horn cells of the spinal cord, but lesions are also widespread in the remainder of the central nervous system. The size of this virus appears to be in the same range of magnitude as that of poliomyelitis virus. Although many contradictory and irregular results have been published on the immunological relationships of both the Columbia SK and MM viruses, Dalldorf's unpublished studies have recently been quoted by Schatz and Plager (9) as indicating that the MM virus is serologically similar to the Columbia SK virus, but different from both the Lansing-type poliomyelitis viruses and the spontaneous mouse encephalomyelitis viruses of Theiler. Although the original human material from patient MM contained a virus which produced poliomyelitis in the rhesus monkey, the MM virus derived from the hamster brain is not pathogenic for monkeys, and apparently no work has been done

to determine whether or not any immunological relationship existed between the monkey-pathogenic virus in the original human material and the virus derived from the hamster brain. Jungeblut and Dalldorf, in their original report (4), stated that the data, "while suggesting that a direct transfer of poliomyelitis virus was obtained from man to hamster—with further transfer from hamster to cotton rats and white mice—are admittedly insufficient actually to prove such transmission. The possibility that accidental contamination may have occurred with a latent virus, or with a virus carried in the laboratory, cannot be ignored." The recent report of F. K. Sanders (8) of a "poliomyelitis-like" virus, unrelated to Lansing virus, picked up during the course of passaging Lansing virus in hamsters, suggests that hamsters, like mice, may perhaps be a source of spontaneous encephalomyelitis viruses or that accidental contamination with a hamster-pathogenic virus present in the laboratory might have occurred.

(iii) *The so-called "encephalomyocarditis" or EMC virus*. This was recovered by Helwig and Schmidt (3) by mouse inoculation from the pleural fluid and spleen of a chimpanzee in Florida, which died exhibiting bilateral hydrothorax, pulmonary edema, pericardial effusion, and myocarditis. This virus, which originally was described as producing paralysis in mice, associated with myelitis and myocarditis, was further studied by Warren and Smadel (11), who, after failing to identify it with "some 20-odd viruses" including the Lansing and Y-SK poliomyelitis viruses, found that serologically (as well as on the basis of its physical and pathogenic properties) it belonged with the MM and Columbia SK viruses.

The Columbia SK, MM, and EMC viruses are highly viscerotropic as well as neuronotropic. None of them gives rise to an experimental disease in monkeys like that produced by the various strains of human poliomyelitis virus, regardless of whether they had been passaged in monkeys, cotton rats, mice, or hamsters. The 1941 preliminary report of Theiler (10) that in his hands the Lansing virus, after prolonged passage in mice, had lost much of its pathogenicity for monkeys (an observation occasionally repeated by others) is often quoted to indicate that monkey pathogenicity may be lost as a result of adaptation of a poliomyelitis virus to other hosts; it should be recalled, however, that the Lansing strain mentioned by Theiler retained its immunological identity as well as its original pathogenic characteristics in mice. The capacity of the Columbia SK, MM, and EMC viruses to produce paralysis in rodents, associated with lesions in the anterior horn cells of the spinal cord, is also exhibited by such viruses as yellow fever, dengue, vesicular stomatitis (the Indiana strain regularly producing primary paralysis of the posterior extremities in intracerebrally inoculated guinea pigs) (7), and, depending on the dose, route of inoculation, age of the animal, also the various members of the encephalitic group, e.g. Japanese B, St. Louis, Russian Spring-Summer, WEE, EEE, etc. Except

in so far as these latter could be classified along with the poliomyelitis viruses as neuronotropic they are not considered as belonging to the group of poliomyelitis viruses. Therefore, it is the opinion of this Committee that there is insufficient justification for the use of the terms "poliomyelitis" or "poliomyelitis-like" in connection with the Columbia SK, MM, EMC, and related viruses.

III. SUMMARY AND RECOMMENDATIONS

(1) The term *poliomyelitis virus* should be used to designate strains of the agent originally described as the cause of poliomyelitis in man and only these. It is identified by the characteristic experimental disease in the monkey, by the character and distribution of histological lesions in the spinal cord and brain of infected primates, by its host range, and by its immunological properties.

(2) Strains of poliomyelitis virus have been distinguished by immunological methods. With the exception of the Lansing group, they are as yet poorly defined. Some strains in this group have special properties of infecting cotton rats, mice, and hamsters, as well as primates. Human sera may contain antibodies to these strains. Because they also satisfy all other identifying criteria, their inclusion as examples of true poliomyelitis virus is justified.

(3) Certain encephalomyelitis viruses of mice, such as Theiler's TO, FA, and GD VII strains, have been

termed "mouse poliomyelitis" by some. This term should be discontinued and Theiler's original designation of *spontaneous mouse encephalomyelitis* used to describe these viruses.

(4) Other viruses which produce paralysis and neuronal lesions in the anterior horns of the spinal cord in experimental animals, but which do not otherwise satisfy the criteria set down for poliomyelitis virus, should not be called "poliomyelitis virus," "mouse poliomyelitis virus," or "poliomyelitis-like virus."

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Some Considerations of Bird Migration

Continental Drift and Bird Migration

The theory of continental drift postulates an original northern land mass, Laurasia, and a southern one, Gondwana. Each eventually broke into several drifting segments which became the present continents. Laurasia and Gondwana were "separated by a vast sea known as the Tethys." To explain some facts of animal distribution it is assumed that Laurasia and Gondwana occasionally drifted near one another or were at times in contact.

Wolfson (*Science*, July 9, pp. 23-30) has sought to explain the long migrations of some species of birds from hemisphere to hemisphere in terms of this theory. He assumes that at those times when the two hypothetical land masses were adjacent, certain birds happened to acquire a short migration that took them from one to the other. As the land masses drifted apart, he believes that such birds continued to migrate from one to the other until their migration may now

extend nearly or quite from the Arctic to the Antarctic.

The theory of continental drift was seized upon by zoogeographers seeking to explain certain supposed anomalies of plant and animal distribution, particularly among fossil forms. Because of the relative scarcity of avian fossils and the unusual powers of dispersal conferred by flight, ornithologists are unable to determine the validity of this theory. Mammals, which are less able to cross water gaps and are represented by numerous fossils, are better material for such investigation.

G. G. Simpson (*Amer. J. Sci.*, 1943, **241**, 1-31), in connection with his extensive studies of fossil and living mammals and their distribution, summarized his conclusions with respect to the theory as follows:

The fact that almost all paleontologists say that paleontological data oppose the various theories of continental drift should, perhaps, obviate further discussion of this

point and would do so were it not that the adherents of these theories all agree that paleontological data do support them. It must be almost unique in scientific history for a group of students admittedly without special competence in a given field thus to reject the all but unanimous verdict of those who do have such competence.

After reviewing the evidence, Simpson concluded:

The known past and present distribution of land mammals cannot be explained by the hypothesis of drifting continents. . . . The distribution of mammals definitely supports the hypothesis that continents were essentially stable throughout the whole time involved in mammalian history [*i.e.* since the Triassic].

More recently Simpson (*Bull. geol. Soc. Amer.*, 1947, 58, 613-688) has shown that North America and Eurasia apparently have occupied their present positions at least throughout the Tertiary, though at times connected by an Alaskan-Siberian land bridge. Even the widely accepted earlier belief in an early Tertiary European-North American land bridge seems now to be contrary to most paleontological evidence. Similarly, the mammalian fauna of Australia is such as to indicate strongly that that continent has been in its present position throughout the era of mammals and not connected with other continents except by an archipelago leading toward Asia, as at present. Even the continental drift proponents admit that the mammals of South America and Africa are so different that these continents must have separated by the beginning of the Tertiary. Wegener himself placed the initiation of separation of Gondwana into continents as pre-Jurassic.

Paleontologists thus think the evidence opposes continental drift, at least since the beginning of the Mesozoic and certainly since the beginning of the Tertiary. In seeking to extend the origin of the migrations of many existing species of birds back to such ancient times, Wolfson writes (p. 26): ". . . by the end of the Cretaceous modern types of birds were well represented. It is conceivable, therefore, that birds were well established and that migratory movements had originated *before* the advent of drift" [*italics his*].

The known Cretaceous birds, such as *Hesperornis* and *Ichthyornis*, though usually from the upper strata of that period, are plentifully supplied with teeth and other primitive characters. There is no reason to believe that modern types were represented at that time, particularly since even among Eocene birds the majority belongs to subfamilies, if not families and orders, distinct from living birds. This will be evident to anyone examining recent works on avian paleontology—for example, the two papers of Wetmore (*Amer. Mus. Nov.*, 1934, No. 711; *Smithsonian Misc. Coll.*, 1940, 99, 1-81.)

Among the many birds that have long migrations from one hemisphere to the other are representatives of several families including such advanced types as warblers (Parulidae), the bobolink (Icteridae), swallows (Hirundinidae), as well as water birds, such as sandpipers (Scolopacidae), terns (Laridae), and many others. That the migratory patterns of these existing species were determined by events which occurred, if at all, at least 70,000,000 years or more ago in the Cretaceous period is not, as Wolfson says, conceivable—it is inconceivable.

A further conclusion of Wolfson's theory is that "Implicit in the present hypothesis is an *origin in the Southern Hemisphere* for those migrants that winter there today" (p. 29, *italics his*). The suggestion that numerous species of northern nesting sandpipers and other birds originated in the Southern Hemisphere because they happen to migrate there is very unconvincing. Many species like the sanderling (*Ereunetes alba*), which may be found in winter from New Jersey to Patagonia, winter in both hemispheres. Others like the warblers of the genus *Dendroica* contain several obviously related species that nest in the north, some of which migrate to the Southern Hemisphere while the others do not. Are we to assume that the former group evolved in South America, the latter in Canada?

Wolfson stated that birds with long interhemispheric migrations have closely related species in the Southern Hemisphere. The particular species he chose to illustrate this, the antarctic tern (*Sterna vittata*), is unfortunate, since Murphy (*Amer. Mus. Nov.*, 1938, No. 977) has shown that it is allied to the other Southern Hemisphere terns and only superficially resembles the arctic tern (*S. paradisaea*). Some long-distance migrants like the bobolink (*Dolichonyx*) have no close relatives in the Southern Hemisphere.

The major shortcomings of this theory of migration have been mentioned; one or two other weaknesses in the evidence presented to support it may be indicated. The migration of the Greenland wheatear (*Oenanthe oenanthe leucorhoa*) from its nesting grounds in Greenland and Baffinland back through western Europe to Africa is mapped. It is suggested that this route arose as America drifted westward away from Eurasia and the birds continued to cross the ever-widening gap. Overlooking the fact that the African portion of this map of the wheatear's range is greatly in error, as Dr. James P. Chapin informs me, it must be noted that this species nests all across northern Eurasia and well into Alaska. The Alaskan wheatears, like several other Alaskan birds of recent Asiatic derivation, migrate back through Asia. To explain this in terms of direction of continental drift, we should have to believe that the east and west coasts

of North America had drifted in toward each other. Most of us will prefer the older theory that a migratory species that has recently extended its range is apt to migrate back along the route of range extension.

Exception must also be taken to the belief that migration is rare in the Southern Hemisphere. If we take into account the much smaller area of land in the southern temperate region as compared with that in the Northern Hemisphere, and the correspondingly smaller number of resident birds, the percentage of migrants in an area such as Tasmania, for example, is much as would be expected in an area of similar climate in the north.

Wolfson makes much of the fact that most bird migration, like most of the assumed continental drift, is northward. Taking it for granted that northern breeding species migrate north, Wolfson then says of the migration of the species that breed in the Southern Hemisphere: "These flights from southern temperate latitudes, it should be noted also, are northward. . . ." Perhaps it is permissible to point out that a similar half truth could be expressed by saying that all migrants go south—in the Northern Hemisphere away from their breeding grounds; in the Southern Hemisphere, toward them.

The possible methods of evolution of long inter-hemispheric migrations have been considered in numerous publications on bird migration. Wolfson's implication that such migrations are in a class by themselves is definitely erroneous. Every degree of migratory behavior from short or occasional flights to long, regular ones exists, and often in closely related species or even within a single species. Indeed, banding has shown that an individual bird may migrate some years and not in others.

Certain species like the sanderling may winter over a great north-south distance. Doubtless in other species of once similar migratory patterns the individuals wintering at intermediate points were gradually eliminated because of poorer survival. The tremendous but gradual changes in climate and in other factors influencing bird migration associated with the glacial periods or other geological cycles unquestionably played a part in molding migratory routes.

Although, as Wolfson states, some birds seem to migrate further than is necessary to find wintering grounds, this cannot be taken for granted until we know vastly more about their winter requirements and about competition with related species wintering in adjacent or less distant areas. That the arctic tern migrates south chiefly through the eastern North Atlantic, for example, may be an entirely adaptive evolution of the most favorable route, resulting from

poorer survival of individuals that once migrated in the western Atlantic. In a thorough study of the migration of this tern, Kullenberg (*Arkiv. Zool.*, 1946, 38A, 1-80) points out that it is partial to cold, plankton-rich waters at all times. This explains its southward migration through the eastern Atlantic, where the cool waters of the Canary and Benguella Currents leave a vastly narrower expanse of tropical water to be crossed than exists in the western Atlantic. Moreover, the use of Mercator projections in Wolfson's maps of the migration of the arctic tern and of the wheatear gives a highly distorted picture of the distances involved.

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Some More Problems in Bird Migration

The very stimulating paper by Albert Wolfson (*Science*, July 9, pp. 23-30) brings to mind two other interesting problems in the riddle of migration in bird life. During the last few years observers on the Mississippi Flyway have been reporting an increase in the number of migrating blue geese, *Chen caerulescens*. The state of Iowa provides an excellent opportunity to note this change. Iowa is bordered by two main flyways, the Central and the Mississippi. The first list published on the birds of Iowa (Keyes and Williams. *Proc. Davenport Acad. Sci.*, 1903, 5, 113-161) makes no mention of the appearance of this species of waterfowl in the state at that time. Although Cooke ("Bird Migration in the Mississippi Valley in 1884 and 1885") reports that it migrates through the Mississippi Valley, it must be remembered that only two Iowa ornithologists contributed data to this report, so it cannot be so complete in that respect. Anderson's "Birds of Iowa" (*Proc. Davenport Acad. Sci.*, 1907, 11, 125-417) listed it as a rare migrant, while DuMont (*Univ. Ia. Stud. nat. Hist.*, 1934, Vol. V) records that it is a recently common migrant along the Missouri River Valley during the spring, though somewhat less numerous during the fall migration. Since 1934 the number of spring migrants has steadily increased to such an abundance that people come from all over the country to view the migration and it has been reported in detail in the press and sporting magazines.

Then the sudden change came. In the spring of 1945 the blue goose used the Mississippi Flyway for the first time. James Harlan (*Ia. Bird Life*, 1945, 15, 48) recorded the spectacle as follows:

. . . A flock of approximately 3,000 Blue and Snow Geese are migrating north up the Mississippi River and are now resting in the Green Bay bottoms. Single Blue

Geese have been noted on the Mississippi rarely in the spring in the past, but since historic times the spring flight of this goose has been north up the Missouri River, with some major flocks spilling inland to the northwest Iowa lakes. Ornithologists have been anticipating a change in the spring concentrations because of an irregularity in the fall flight pattern recently. Bird students attribute this flight change to the advent of the mechanical cornpicker, which shatters and leaves lying on the ground thousands of bushels of readily available waste corn.

It would be interesting to know exactly how the flight patterns of birds originated and if they have remained the same during the centuries. For an example, take the case of the common migrant, the white-throated sparrow. A recent study by two bird banders (*Auk*, 1948, 65, 402-418), in cooperation with other banders who had placed 43,000 tags on this species of finch, proved that some individuals change the flyway that they had been using. A total of 10 individuals were found to have crossed from one flyway to another; for example, one bird starts the migration on the Atlantic Flyway and then crosses over to the Mississippi Flyway. As far as we know, this may be the case with all of our common migrants. The solution will come only from intensive and cooperative banding operations over the entire continent.

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Bird Migration and Magnetic Meridians

In "Bird Migration and the Concept of Continental Drift" (*Science*, July 9, pp. 23-30) Wolfson mentions several times the *eastward* flight of the arctic tern across the North Atlantic and asks: "Is it merely coincidence that the direction of flight is in accord with the pattern of drift? If so, how then, can one explain the east-west flight across the North Atlantic. . . .?"

One possible explanation, which, however, does not conflict with Wolfson's main thesis, is suggested by the fact that if the flight path is referred to magnetic direction, it is seen that the migratory path is approximately magnetic south. To be more precise, if the arctic tern maintained a magnetic heading of south, paralleling the magnetic meridians, on its overwater flight, the resultant of this heading and the prevailing winds of the North Atlantic would be the observed migratory flight path.

Other birds also seem to hold a flight heading parallel to the magnetic meridians in their migratory flights. The overwater flight of the golden plover from Nova Scotia to the mainland of South America also can be regarded as the resultant of a heading of magnetic south and the prevailing winds of the area.

These two cases suggest the possibility that on long, overwater, migratory flights all birds maintain a heading parallel to the magnetic meridians and that their flight path is a resultant of this heading and the wind at the time of flight.

It is suggested that a study of overwater migration as a navigational problem with consideration given to heading, speed of flight, and prevailing winds at the time of migration may clear up seeming anomalies in direction of migration, such as the eastward flight of the arctic tern.

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Bird Migration and Pressure Patterns

In a recent interesting article, Wolfson discusses a new hypothesis which attempts to explain the paths of migration of birds (*Science*, July 9, pp. 23-30). It is not intended to comment on the biological and geological questions raised in this paper. It seems apropos, however, to present a few points that occur to a meteorologist in this connection.

In Wolfson's paper there is no direct reference to the effect of winds on the migration of birds. Birds, after all, have only a limited amount of power available for their movements. Obviously, they will be seriously affected in their migrations by currents in the atmosphere. It is unlikely that they would be in a position to battle head winds for long periods of time.

What strikes the meteorologist in looking at the migration paths shown in Figs. 4, 5, and 6 of Wolfson's paper is the resemblance to certain generalized trajectories of air currents. For example, in the migration of the arctic tern one can observe a close correspondence to the trajectories of the most frequent winds in the late fall and early winter. These winds are northwesterly in the Baffin Bay area, then turn to westerly in the North Atlantic between the North American continent, the southern tip of Greenland, and England. They turn to northerly over western Europe and northeasterly in northwest Africa. The path of migration shows over the North Atlantic a flight pattern around the Middle Atlantic high-pressure cell, commonly known as the Bermuda-Azores High. The recurving of the flight path to eastern South America follows the trajectory of the northeasterly trade winds in the very early parts of the winter. These trade winds reach and occasionally cross the equator in the South American area. Northeast or eastnortheast winds are still prevalent during this season as far south as 35° southern latitude along the east coast of South America. South of that area, especially somewhat off-shore, northerly and north-

westerly winds prevail at the west edge of the central high-pressure cell in the South Atlantic. This could easily facilitate the drifting of the birds into the middle of the South Atlantic.

It is similarly interesting that the Greenland wheatear follows a path across the Atlantic and along the African shores which resembles the general trajectory of air in the late fall. In migrating along the African shore, these birds would encounter in the early parts of the winter fairly strong southerly wind components near the equator in the area of the Gulf of Guinea, which might be a contributory cause for stopping them in this general region.

The migration of the Pacific golden plover also shows rather unmistakable signs of a wind-pattern correlation. In the fall, when the Siberian high-pressure cell begins to re-establish itself, northerly components of winds are the rule in the areas of Kamchatka and Japan. These turn to northeasterly components south of Japan and continue in that direction to the equator. Somewhat later in the season, just south of the equator, the trajectories change to northwest and continue with that direction through the island belt of the Dutch East Indies into northern Australia.

It is also noteworthy that Wolfson mentions that the greater shearwater moves back from the middle of the South Atlantic on the western side of the North Atlantic Ocean to high latitudes in spring and summer. This flight path follows a general air trajectory first in the southeast trade and then north of the equator, in air currents on the southern and western side of the Bermuda-Azores high-pressure ridge. In addition, Wolfson states that birds of the Southern Hemisphere do not migrate as far as birds from the Northern Hemisphere. Meteorologically, there is a considerable difference between the general circulation of the atmosphere in the moderate latitudes of the two hemispheres. The general pressure patterns in the Northern Hemisphere change radically with the seasons. In the Southern Hemisphere there is relatively little change in the fundamental pressure patterns, especially over the oceans. The belt of westerly winds in the Southern Hemisphere is also very strong throughout the year, and it would probably be very difficult for a bird to break through the so-called Roaring Forties.

To the meteorologist, it looks as if some of these migratory birds had developed a rather remarkable system of what is called in modern aviation "pressure-pattern flying." This is the system which takes advantage of the maximum possible amount of tail wind in long-distance flights. Since the data collected on these migratory birds are essentially based on records

from long years of observations, they should most closely resemble the mean wind conditions as we find them on climatological charts. In any individual year the migration would, of course, be governed by the prevailing conditions at that time, and hence a certain amount of scatter in the recovery of banded birds can be expected.

If powerful modern aircraft, for reasons of economy and safety, adopt the system of pressure-pattern flying, it seems reasonable that birds, which are much more dependent upon assistance offered by these air currents, would follow the path of least resistance. The general circulation patterns in the atmosphere have, of course, changed throughout geological history. If there had once been in existence just one major land mass, the general circulation would have been entirely different. In fact, it would be very difficult to visualize a circulation pattern under those circumstances that would resemble the patterns prevailing in the present geological era. The winds prevailing over a single continental mass, as envisaged by the hypothesis of continental drift, would in its seasonal variations be completely at variance with present conditions. These currents would have forced birds to migrate along entirely different paths than at present. It would seem desirable that any hypothesis of bird migration, such as the one proposed by Wolfson, should include a very careful analysis of present and presumed past patterns of atmospheric currents.

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Bird Migration Over the Mediterranean

I read with interest the article by Griffin and Hock (*Science*, April 2, pp. 347-349) on the homing of gannets in America. This contained mention of a belief that migrating birds flew in straight lines. My "Notes on the Migration of Birds Over the Mediterranean Sea" (*Brit. Birds*, 1919, **13**, 173) tends to show that birds stick to coast lines as much as possible, or to routes where they can see land. They do not cross the Mediterranean at any haphazard place; they stick to one of four routes: (1) the well-substantiated Gibraltar route (not discussed in my article); (2) Cape Bon-Sardinia-Riviera (land bridge in Upper Eocene and Oligocene ages, later broken up into a chain of islands); (3) Malta-Sicily-Italy (land bridge in early Pleistocene); and (4) Egypt-Crete-Greece (never a land bridge, but with land visible all the way to a bird flying high in good weather).

The Cretan route provided me with $4\frac{1}{2}$ times as many observation days of migrating birds and $2\frac{1}{2}$ times as many birds (1.8 as many species) as did the Sardinian

route. My observations or discovery of these last three routes was apparently new at the date of publication, and *Ibis* abstracted my article.

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Sensitivity of the Homing Pigeon to the Magnetic Field of the Earth

H. L. Yeagley has proposed the theory that the homing pigeon navigates to its loft because of sensitivity to the magnetic field of the earth and to the Coriolis force (*J. appl. Phys.*, 1947, **18**, 1035). The intersecting magnetic and Coriolis fields give a grid effect such that each point on the surface of the earth is characterized by a unique or almost unique combination of the two forces. The pigeon orients himself to the point on the earth having the "local sign" of his aviary, which is familiar to him. This theory, supported by a series of ingenious experiments, seems to offer a fresh explanation of what has long been considered a most puzzling biological phenomenon.

The theory has been severely criticized for its theoretical assumptions (L. Davis. *J. appl. Phys.*, 1948, **19**, 307; Linnean Society of London. *Nature, Lond.*, 1948, **161**, 996; J. Slepian. *J. appl. Phys.*, 1948, **19**, 306; R. H. Varian. *J. appl. Phys.*, 1948, **19**, 306).

(1) The bird would have to be sensitive to extremely minute gradients of the physical forces involved in order to navigate in the correct direction. Disturbing influences such as static charges in the atmosphere must be disregarded.

(2) The bird would have to gauge its speed of motion over the earth with extraordinary accuracy. The emf supposedly induced in the pigeon by the magnetic field of the earth is related to the speed of the bird in traversing the field. To sense correctly the strength of the magnetic field of the earth, the bird would have to know its own speed.

(3) The theory assumes the sudden emergence in the bird of sensitivities which have never been established for the lower classes of animals. The probability of two sensory capacities spontaneously arising at a given evolutionary level would seem to the biologist to be very remote.

While these theoretical criticisms weigh against the theory, no theoretical argument can cast aside the basic fact of pigeons returning, or failing to return, under experimental circumstances designed to test the effect of the earth's magnetic field, and the Coriolis force. Unless there is some fault in the setup of the experiments (several possibilities have been mentioned by the Linnean Society of London), homing would seem to be due to the sensitivities mentioned or to somehow

related sensitivities. Repetition of these observations is definitely indicated.

The author has repeated, with certain modifications, an experiment of Yeagley's which supported the view that sensitivity to the earth's magnetic field plays a part in bird navigation. In the original experiment, 10 birds with magnets and 10 with copper plates of the same approximate mass and size were released by Yeagley at a point 65 miles from the home base. Yeagley believed that the pulsating magnets might induce in the bird's anatomy an oscillating emf which would confuse the perception of the earth's magnetic field. The following figures were given for number of birds returning:

Nov.	Day	Two copper plates	Two magnets	Lost one magnet	Lost two magnets
7	1st	5	—	1	—
8	2nd	3	—	—	—
9	3rd	—	—	—	—
10	4th	—	1	2	2
Total		8			6

These results are suggestive of an interfering effect due to the attachment of the magnets but cannot be regarded as showing such an effect conclusively. The experiment employed only 20 birds; magnets fell from the wings of the birds in the magnet group; the difference in returns was inconclusive (6 birds in the magnet group as against 8 birds in the control group).

The 60 homing pigeons employed in the present experiment were raised at the Pigeon Breeding Center of the U. S. Army, at Fort Monmouth, New Jersey. The birds were between the ages of 3 and 6 months and had been trained on several preliminary flights. Three experimental groups were used: (1) 24 birds which carried magnets of high-flux chrome, size 1" x .218" x .025" on their wings; (2) 24 control birds which carried *unmagnetized* high-flux chrome bars of the same size and weight as the previous group; and (3) 12 birds which carried no weights. The latter group was included to test the effect of attaching weights to the wings of the other birds. The magnets and slugs were glued with Duco cement on the under side of the manus portion of the wings, between the third and fourth metacarpal bones, as described by Yeagley. No magnets or slugs fell off during the runs.

The birds were released from three points—36, 50, and 58 miles distant from the aviaries—selected to allow an analysis of the disturbing effect of the mag-

¹ The pigeons were raised under the direction of Maj. Otto Meyer, chief pigeonier, Army Signal Corps. The author wishes to acknowledge the valuable help of Mr. Leon Zinner, who assisted in the work.

birds as related to the distance of flight from the aviary. The points of release were in the southwesterly direction, in unfamiliar territory. The direction of flight was such that the birds had to navigate across the gradient of the magnetic field.

The constitution of each of the three groups of pigeons released in this experiment was as follows: 8 with magnets, 8 with slugs, and 4 with no attachments.

Pigeons were released from the three distances simultaneously at 6:30 A.M. on August 27, 1948. They were released singly, with 10 minutes between tosses. No bird was liberated if the last bird was still in sight. The order of release provided for rotation among the magnetic, slug, and control groups.

Results showed that *every bird used in this experiment returned home before nightfall of the day of release*. Time records are incomplete, but are given below for birds clocked on entrance to the aviaries.

	36 miles	50 miles	58 miles
No attachments	Median, 163.5 min (2 birds)	Median, 104 min (4 birds)	Median, 400.5 min (2 birds)
	Mean time, 213.4 min (8 birds)		
Slugs attached	Median, 95 min (6 birds)	Median, 133.5 min (8 birds)	Median, 171.5 min (4 birds)
	Mean time, 162.0 min (18 birds)		
Magnets attached	Median, 106 min (4 birds)	Median, 111 min (5 birds)	Median, 180 min (6 birds)
	Mean time, 160.3 min (15 birds)		

Analysis of these time records shows that the birds with magnets attached returned as quickly as the others. It is not known why birds with no weights attached flew more slowly than the others. Emotional effects may have increased the speed of flying in the magnetic and slug groups.

This experiment fails to show any effect on homing due to the attachment of magnets and the emf supposedly induced in the birds by oscillation of the wings. It is suggested that other experiments of

similar nature be carried out in the attempt to see if the unusual results reported by Yeagley can be verified by another observer. If these results can be duplicated, experimentation might well proceed to the isolation of the particular sensitivities involved by such techniques as the reward and punishment methods of comparative psychology.

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On Continental Drift and Bird Migration

With respect to Dr. Wolfson's illuminating and clearly thought-out paper (*Science*, July 9, pp. 23-30), I would like to point out the important distinction between changes in the configuration of continents and ocean basins that may be brought about and have been brought about, as we know through ample evidence, by deformation of the earth's crust, rising continents, subsiding basins, etc.—the distinction, I say, between such deformation, with consequent changes in configuration of land and sea, and *the concept of continental drift as such*.

I suspect Dr. Wolfson's brilliant hypotheses could equally well conform to changes in the face of the earth, to changes in paleogeography, that did not arise through continental drift, but in consequence of other modes of crustal deformation.

That where once there was land, there may now be the waters of the Atlantic and that such a change could have brought about the evolution of migratory birds seems plausible and exciting; that it follows that continental drift was the cause of the changed distribution of land and water does not necessarily follow and is *quite a different problem*.

Dr. Wolfson's thoughtful paper, nevertheless, remains a stimulating contribution, and I agree that "if biologists have an adequate knowledge of the properties, requirements, and behavior of organisms, and have confidence in that knowledge, they can make substantial contribution to our knowledge of the earth's history."

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The Colchicine and Colchicine-like Reaction as a Possible Response to Enzymic Poisoning

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The gross effect of respiratory poisons and their antagonism by cellular extracts have been described for the root tips of the onion *Allium Cepa* L. (6). The present report is an extension of these investigations to the cytologic response of the roots to the same poisons and a comparison of these characteristics with those following exposure to colchicine.

Basic phenylmercuric nitrate and phenylmercuric hydroxide are strong polyploidogenic agents in the meristematic cells of the onion root, as was shown by the partial inhibition of spindle formation in dividing cells at the end of 5 hrs of exposure to 0.1 ppm of the mercurial compounds in water. Within 24 hrs after exposure a typical colchicine-like reaction developed cytologically, with the presence of blocked metaphases characterized by overcondensed chromosomes and diplochromosomes in acetocarmine staining of squash preparations. The same picture developed after 1 hr of exposure to 10 parts of poison in 1 million parts of water. Recovery from these sublethal effects of the poisons followed the same sequence as that observed following colchicine treatment—that is, lobed restitution nuclei, multinucleate cells, multipolar spindles, and normal mitosis in diploid and polyploid nuclei in the same tissue. So sensitive was the onion root meristem to the phenylmercuric nitrate and phenylmercuric hydroxide that exposure at $25 \pm 2^\circ$ C to 1 part of the mercurial compound in 20, 40, and 80 million parts of water for 24 hrs resulted in partial inhibition of spindle formation and some tetraploid nuclei.

The cells first succumbing to the near-lethal dilutions of the phenylmercuric nitrate and phenylmercuric hydroxide were those just behind the meristem. In those roots recovering from continuous exposure to the mercurials at the lethal threshold (0.1 ppm of water), these cells enlarged isodiametrically instead of in the vertical plane, resulting in the so-called c-tumor or colchicine tumor of Levan (5). When these swollen tips were returned to water after 48–72 hrs in the poison, some continued to grow slowly in the clubbed form. In these tips the meristem was much reduced, and differentiation of the protoxylem strands extended to the promeristem. The same type of premature differentiation of protoxylem in onion roots after colchicine treatment was described

by Eigsti (3) and was an irreversible cytoplasmic effect of the poisoning.

Bulbs bearing both untreated normal roots and roots with thickened (1–2 cm), elongated tips having polyploid nuclei as the result of previous exposure to sublethal concentrations of a mercurial were placed for 3 days over a solution of phenylmercuric nitrate (1 part in 3 million, 5.3×10^{-7} M). The normal roots became flaccid and died. The roots with hypertrophied tips remained turgid and grossly unchanged during the second period of exposure to the poison.

Ethyl mercury phosphate (7, 8) and ethyl mercuric chloride (11) have effects similar to those of phenylmercuric nitrate, phenylmercuric hydroxide, and colchicine on the meristem. The cells of the onion root were far more sensitive to phenylmercuric nitrate than were some microorganisms (10) and some enzyme systems (1). The action of the poison on the roots may be cumulative, as deduced by Dustin (2) from the work of Sass (7).

The observations reported herein would suggest that the colchicine and the colchicine-like reactions to mercurial poisons may be an adaptive mechanism of plant cells in the presence of an enzymic poison, as recently suggested for animal cells by Dustin (2), since basic phenylmercuric nitrate is a respiratory poison which probably attacks the -SH groups of succinic dehydrogenase and also inhibits lactic and glucose dehydrogenases as well as cytochrome oxidase and catalase (1).

An increase in the number of chromosomes in plants results in slower growth and lower growth energy (5). With the induction of polyploidy there is a decrease in the ratio of surface area to volume in protoplast and nucleus, whereas the reverse is true of the chromosomes. Levan (4) tested the sensitivity of diploid and tetraploid seedlings of barley, oats, and rye to colchicine, observing in a few instances that some concentrations affected the diploid cells earlier and more markedly than the tetraploid cells; he attributed the difference in response to the difference in the growth rate of the two types of cells. In our experiments the increased resistance of the hypertrophied root tips to re-exposure to the poisons may have been due to their reduced growth rate, premature differentiation, and the cuboidal form of the cells behind the meristem.

The presence of polyploidy and of polytene chromosomes in some tissues of diploid plants and animals would suggest an adaptation of the cell to an unfavorable environment for enzyme reactions. The cancer process is considered by Spencer (9) as a type of cell adaptation to an unfavorable environment, a survival mechanism, and Levan and Ostergren (5) have attempted to equate the actions of colchicine and carcinogens. The similarity of the colchicine reaction and the colchicine-like reaction to

mercurial respiratory poisons in onion root tips emphasizes the difference between the colchicine response and cytologic characteristics in carcinogenesis, since colchicine produces (a) an immediate reversible inhibitory effect on the cytoplasm of dividing cells without arresting chromosomal reproduction, (b) a delayed irreversible decrease in the rate of cell division, and (c) an increase in the rate of cellular differentiation.

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The Crystalline Form of Sodium Ascorbate¹

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The desirability of a stable, neutral, dry salt of ascorbic acid had been felt virtually from the moment of the discovery that ascorbic acid was vitamin C, but the rapid decomposition of ascorbic acid in the presence of alkali seemed to make this a hopeless search. Sherman (3), Thorpe (4), and others described the destructive action of alkali on ascorbic acid. Karrer (1) in 1933 had tried to secure a dry salt by reacting sodium ethylate in ethyl alcohol but indicated that rapid decomposition readily resulted. So certain did it appear that a stable sodium salt would not exist that in the intervening years not a single further publication appeared on the subject, nor was any dry sodium ascorbate made available.

A therapeutically useful crystalline sodium ascorbic was finally attained through reaction of sodium methylate in methyl alcohol (2). Surprisingly, this yielded a product of remarkable stability exceeding that of ascorbic acid itself. After 500 hrs aging at 45° C in closed glass containers, the sodium ascorbate showed no decline in ascorbic acid potency. Pure crystals were obtained which could successfully be used for seeding concentrated syrups of sodium ascorbate with a high yield of crystalline sodium ascorbate. The preparation of sodium ascorbate with sodium methylate in methyl alcohol was conducted as follows.

¹This research was conducted under a grant from the Physiological Chemicals Company, Inc., who also supplied the sodium ascorbate (Natri-C).

Eighty-eight gm (0.5 mole) of ascorbic acid was dissolved in 600 cc of hot absolute methyl alcohol. While still hot, it was treated under stirring with 250 cc of a warm solution of sodium methylate containing 12.5 gm of sodium (theory, 11.5 gm). The combined solutions were stirred until the resulting precipitate of sodium ascorbate turned crystalline. This took about 15 min. The sodium ascorbate was then filtered with suction and washed with a little methyl alcohol. It could be dried *in vacuo* at a temperature as high as 100° C. The yield was 95% and the product 100% pure.

Once stable crystals were obtained in the laboratory, seeding was undertaken to perfect the formation and was readily accomplished despite the alkaline nature of the reaction. It seems to be a common laboratory experience that, once the crystals are obtained in the laboratory, solutions previously difficult to crystallize do so very readily.

The explanation for the formation of stable crystals may be sought in the location of the neutralization. The U.S.P. (XIII, p. 898) gives the structural formula of sodium ascorbate as $\text{CH}_2\text{OH}(\text{CHOH})_2\text{COH}:\text{COHCOONa}$, mol.wt. 216.13. It is commonly believed, however, that the neutralization involves a hydroxyl group and that there would be quite a difference in reactivity, depending upon whether the second or third hydroxyl is the location of the neutralization. The third carbon is apparently much more reactive than the second, and its neutralization may produce greater stability. Karrer (1) points out that an excess of ethylate solution must be avoided, as otherwise the yield is greatly reduced. He states that "apparently there then occurs also neutralization of the enolic hydroxyl and decomposition processes of the sensitive substance also occur." Karrer's interpretation would include not only neutralization of the carboxyl but also, in some instances, of the enolic hydroxyl, thus suggesting that two reactions may proceed simultaneously. With the methylate, apparently a single hydroxyl reaction occurs with a uniform hydroxyl reaction of remarkable stability. This would also seem to be the case from the petrographic studies of the crystals, which showed cryptocrystalline formation with the ethylate, a good degree of pure crystals with the methylate and on seeding from the methylate from concentrated syrup.

The crystals showed the following analysis:

Rotation, +102.99.

Iodine titration, ascorbic acid, 87.55; theory, 88.9

Analysis:

	Found	Theory
Sodium	11.33	11.61
Carbon	35.93	36.37
Hydrogen	3.68	3.58

Analysis indicates about 1% water held by crystals.

Further procedures were developed using sodium hydroxide, sodium carbonate, or sodium hydride with similar results.

Petrographic studies conducted by Dr. Wilbur G. Valentine showed the variety of crystallization that may occur and throws light on the possible explanation that the stability of sodium ascorbate may depend also on the

state of aggregation. A similar instance is known to occur in the remarkable stability of the dihydrate of calcium ascorbate as compared to the nonhydrated form, as shown in a previous paper.

X-ray diffraction studies by Dr. Fankuchen gave the following values:

<i>d</i> in Angstrom Units	Intensities
9.93	M
4.82	S
4.52	V.W.
4.27	V.W.
4.05	V.S.
3.66	S
3.38	S
3.20	W
3.11	S
2.94	W
2.80	M
2.61	M
2.40	W
2.30	W
2.26	M
2.14	M
2.08	M
1.98	M
1.91	W
1.81	W

X-ray diffraction studies were made comparing the material made by the ethyl alcohol procedure. Methyl alcohol and water-solution crystals seeded with the methyl alcohol crystals. The material made from the

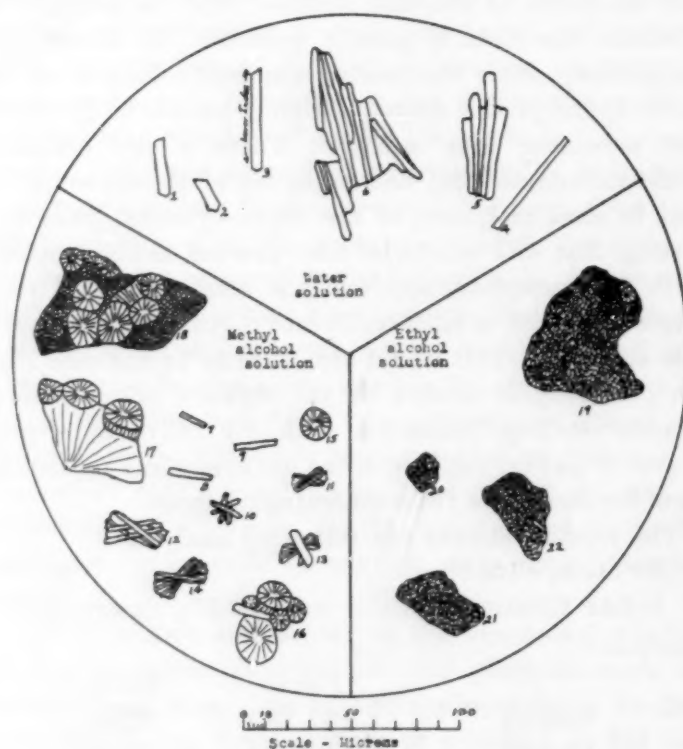


FIG. 1

ethyl alcohol, while having the same general structure as the others, showed a difference on some lines due, obviously, to an impurity. This was particularly true of the line 2.95 Å, which is appreciably stronger in the water crystals than in the ethyl alcohol material. There is also a weak line in the water crystals at 6.16 Å which is not observed in the other material.

Camera lucida drawings of representative fragments

from each of the three samples studied are shown in Fig. 1.

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Effect of Hyaluronidase and of Hyaluronic Acid on Cultures of Trypanosomes, *Leishmania*, and *Amoebae*

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Hyaluronic acid, a complex polysaccharide, and its specific enzyme, hyaluronidase, form a biological system of mucoid structure common to bacterial and animal (including human) species (1, 2). In the present work we have sought to determine the respective effects of the acid and the enzyme *in vitro* upon *Leishmania donovani*, *Trypanosoma cruzi*, and *Endamoeba histolytica*, using hyaluronidase from bovine testes and hyaluronic acid from human umbilical cord.¹

L. donovani and *T. cruzi* were grown on Seneca's medium (3) for 7-10 days. Direct observations were then made upon organisms suspended in saline containing 50 units of hyaluronidase/cc or suspended in 0.5% hyaluronic acid solution for varying lengths of time from 15 min to 4 days. Observations were made on cultures in 5 cc of physiological saline containing 1½, 2½, 5, and 10 units of hyaluronidase, inoculated from the 7- to 10-day cultures and serially transplanted weekly, to identical media and concentrations, for 12 transplants, and on similar 5-cc cultures containing 5 or 1 mg of hyaluronic acid in 5 cc, transplanted weekly for 5 transplants. Microscopic study was done to find the number, viability, and motility of the respective organisms at various times.

E. histolytica of the Denton strain was taken from culture, suspended for direct observation in saline containing 5 units of hyaluronidase/cc, and observed for 48 hrs. Observations were made on cultures prepared by inoculating *Amoebae* with 5 cc of buffered saline containing 1½, 2½, 5, and 10 units of hyaluronidase, overlaid on *Amoeba* culture medium; subcultures were done 3 times weekly, covering 50 generations over a period of 4 months. Similar direct observations were made using 0.5, 0.25, 0.125, 0.0625, and 0.03125% hyaluronic acid in saline and in cultures treated with 1 mg of hyaluronic acid in 5 cc of saline, with subcultures to 5 generations.

The results were as follows:

Hyaluronidase. *L. donovani* and *T. cruzi* were unaffected by direct treatment with hyaluronidase or by

¹ Preparations were made by the Chemical Division of the Schering Corporation.

culturing in its presence; rate of multiplication, vitality, and motility remained the same as in control preparations. *E. histolytica* suspended in solutions of hyaluronidase showed a type of hypermotility, but no changes in vitality or structure. Serial transplantations over 50 generations of *Amoebae* showed that there was enhancement of growth in the presence of hyaluronidase, so that more abundant cultures resulted.

Hyaluronic acid. Hemoflagellates suspended in 0.5% hyaluronic acid showed a steady reduction in motility, particularly of *Leishmania*, but without evidence that the organisms were killed. Serial cultures in the presence of hyaluronic acid showed no effect on the rate of multiplication, vitality, or motility of the organisms over 5 generations. *E. histolytica* exposed directly to hyaluronic acid showed certain structural changes, consisting of hyalinization of the organism and progressive degeneration and rupture, until all the *Amoebae* disappeared. These changes were complete in 15 min with the 0.5% solution of hyaluronic acid and in 70 min with the 0.25% solution; they consisted only of progressive weakening of ameboid activity in 2 hrs with 0.125% solution, while weaker solutions had no effect in 3 hrs. *Amoebae* grown in the presence of 5 mg of hyaluronic acid/5 cc were killed in the 3rd generation; 1 mg/5 cc, in the 5th generation.

Hyaluronidase and hyaluronic acid have indifferent effect upon the hemoflagellates tested. These substances are, however, markedly stimulating and markedly toxic, respectively, to growing cultures of *E. histolytica*; both findings suggest a certain usefulness in culturing *Amoebae* or in attempting to treat amebic infections. While it is not known that *Amoebae* utilize hyaluronidase to invade the host intestine, the observed effect of hyaluronic acid suggests that, if it be used therapeutically, an action both upon the protozoon and upon its power to invade the tissues might be obtained, the latter by inhibition of hyaluronidase possibly secreted by the invader.

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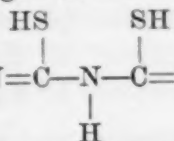
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Responses of Cuttings, Seeds, and Flowers to Dithiobiuret

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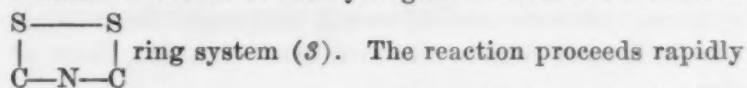
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Molecular structures that embody reduced forms of sulfur (such as -SH groups) and of nitrogen are of general interest to physiologists, and it is well known that the activity of sulfhydryl groups is influenced by the number and position of neighboring nitrogen atoms in the



molecule. Therefore, dithiobiuret, since it embodies two -SH groups symmetrically arranged with respect to three -NH groups, and since it is capable

of serving not only as an H donor but as a source of S and of N as well, should be expected to possess some interesting biological properties. The compound is easily oxidized with loss of two hydrogens to form a 5-membered



The reaction proceeds rapidly and reversibly over the pH range 0.05-5.2 (3). Dithiobiuret operates as a reducing agent at hydrogen-ion concentrations within the biological range also, as is testified by its ability even in low concentrations (0.0005 M) to decolorize rapidly toluylene blue in solutions ranging up to pH values of 7.5 (higher pH values not studied). This dye is but slowly reduced by cysteine (1).

This report presents some observations on the response of vine cuttings, germinating seeds, and cut flowers to dithiobiuret,¹ which for convenience will be designated as DTB in the remainder of this report.

Vine cuttings. Cuttings of grape vines (*Vitis treleasei*) with their bases immersed in distilled water normally developed, within 2 weeks, shoots from the upper bud and roots from the lower node. Cuttings similarly placed in solutions containing 20-80 mg of DTB/liter of distilled water developed short roots and stunted shoots from buds, irrespective of the relative position of the bud on the stem. When such cuttings were transferred to distilled water, the roots promptly elongated. Similar tendencies have been observed with cuttings of *Ficus gnaphtholocarpa* (2).

Cuttings in 0.05 M solution of KH_2PO_4 did not develop any roots in 2 weeks; DTB at 20-80 mg/liter in the phosphate buffer did not invert polarity but had a striking effect in promoting the differentiation of root initials not only from the basal node but all along the basal internodes. Potassium acid phosphate retarded early development of roots and of buds as compared with distilled water, but favored cambial growth at the base of the cutting as well as differentiation of floral organs. Both of the latter effects were enhanced by the presence of DTB. In KH_2PO_4 the increase in diameter was accompanied by longitudinal splitting of the bark and later on by differentiation of root initials, which attained a length of about 10 cm after 3 weeks. Conversely, in $\text{KH}_2\text{PO}_4 + \text{DTB}$ (20 mg/liter) a few root initials differentiated into roots, and these elongated, but slowly, averaging 2.5 cm after 3 weeks. Most of the root initials coalesced into an undifferentiated mass of cells, while the base of each cutting swelled into a tumor-like mass.

Early growth of seedlings under semianaerobic conditions. Seeds of rice (*Oryza sativa* var. Calora) were immersed under 3 cm of a simple nutrient solution (KH_2PO_4 , 0.03 M; $\text{Ca}(\text{NO}_3)_2$, 0.02 M; and $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$, 0.01 M) or of nutrient plus DTB. Addition of DTB in concentrations less than 10 mg/liter had a depressing effect on germination and on growth of roots and coleoptiles. Concentrations of from 10 to 25 mg/liter were strikingly beneficial, leaves developing to a length of 70 mm in 17

¹ We wish to thank the American Cyanamid Company, New York City, for samples of dithiobiuret; L. Flint, Louisiana State University, for seeds of rye grass; and H. P. Olmo, University of California College of Agriculture, for the vine cuttings.

days. Higher concentrations were less beneficial, so that at 100 mg/liter germination and growth were scarcely better than in the control, where leaves were 25–30 mm in length. Similar results were obtained with seeds of ryegrass (*Lolium multiflorum*), although these seeds benefited from higher concentrations than did those of rice.

Response of cut flowers. The observation that appropriate concentrations of DTB prevented discoloration of the basal section of cuttings and prolonged survival of rooted cuttings of the vine, fig, and other plants suggested that this compound might be used to delay wilting of cut flowers. This idea was tested experimentally with Shasta daisy (*Chrysanthemum maximum*) and with marigold (*Calendula officinalis*), both of which remained turgid 1–2 days longer upon addition of 1–10 mg of DTB/liter of tap water or of 0.1 M solution of KH_2PO_4 in tap water. A characteristic response of flowers with their stalks in solutions of DTB was an epinastic curvature beginning at the tips of the ray florets and progressing inward over a period of several days. It is known that solutions of molybdenum salts which form complexes with phenolic compounds favor survival of cut flowers. Likewise, DTB may be surmised to exert its favorable effect by protecting phenolic compounds against oxidation. In this connection it is interesting to note that another strong reducing agent, hydrazine sulfate, is advertised as preserving cut flowers (*Chem. Eng. News*, 1948, 26, 1452).

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Effect of Dietary Factors on Early Mortality and Hemoglobinuria in Rats Following Administration of Alloxan¹

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According to recent studies of Houssay and Martinez (6), alloxan diabetes and its accompanying toxic manifestations in the white rat may be considerably influenced by a variety of dietary factors. In the light of their experimental observations, they concluded that rations low in protein or high in lard reduced, and diets high in coconut oil, or supplements of methionine or thiouracil, increased the resistance of rats to alloxan. Substitution of butter or olive oil for lard or supplements of choline were without any appreciable effect. Oleomargarine and corn oil were slightly beneficial. It was previously known (8) that cystine (cysteine), when given just prior to alloxan, may also counteract the toxic effect of alloxan.

¹ Supported by a grant of Swift & Co., Chicago.

The grouping of the above noxious and beneficial dietary agents is reminiscent of, and almost analogous with, that which governs to a considerable extent the production of massive hepatic necrosis (cf. 1, 5). There is only one important gap in this comparison. This concerns tocopherol, which is known (2, 9) to be an important additional protective factor in the etiology of massive hepatic necrosis. The experiments of Houssay and Martinez contain no specific information on the possible role of tocopherol in the prevention of alloxan intoxication. In fact, the rations used by them seemed to be rather low in tocopherol, and, in consequence, deficiency of tocopherol might have complicated the experimental findings.

Houssay and Martinez judged the beneficial or deleterious effect of a given ration by the number of rats which survived one week after administration of alloxan. They inferred that a lower mortality is a reliable indicator for increased resistance to the toxic and diabetogenic effect of alloxan.

The possibility that tocopherol may exert the same beneficial protective effect on necrotic changes in the pancreas (liver, kidneys, 4) following administration of alloxan, as it does in the prevention of massive dietary hepatic necrosis in rats, made a special study of its role in alloxan intoxication desirable.

In accordance with the experimental technique followed by Houssay and Martinez, female rats weighing between 90 and 120 gm were divided into several groups and fed different rations for a period of one month. All rats were of the Sprague-Dawley strain and were housed in separate cages. After one month and an all-night fasting, the rats were injected intraperitoneally with 160 mg/kg of alloxan (Alloxan-monohydrate, Eastman Kodak), in the form of a freshly prepared solution. To make the alloxan experiments more comparable to those which dealt with dietary hepatic injury, slight modifications in the composition of the rations were introduced. Whereas the diets used by Houssay and Martinez were composed largely of crude natural food constituents, such as wheat flour, corn flour, yeast, and fats, we have substituted in our rations sucrose for flour and, in one group of the experiments, also omitted yeast from the diet. As vegetable fat we used, in addition to coconut oil, a partially hydrogenated shortening, Vream (Swift & Co.). Houssay and Martinez relied on yeast as a source of the vitamin B complex. We supplemented our diets, regardless of whether or not they contained yeast, as a matter of daily routine, with 20 µg of thiamine, 25 µg of riboflavin, 20 µg of pyridoxine, and 100 µg of calcium pantothenate, dissolved in 1 ml of water. The fat-soluble vitamins A and D were given, as in the experiments of Houssay and Martinez, in the form of cod-liver oil incorporated in the diet, except that the special rations (17–20) low in fat were supplemented with 3 drops of corn oil daily and 3 drops of percomorph oil once a week. The daily doses of tocopherol² in the respective groups were 3 mg; of methionine,³ 50 mg; and of choline, 25 mg.

² Mixed natural tocopherols were kindly furnished by Distillation Products, Inc., Rochester, New York.

³ Kindly furnished by Wyeth Inc., Philadelphia

Food intake and changes in weight were recorded for all rats throughout the whole experimental period. Determinations of blood sugar and nonprotein-nitrogen were repeatedly carried out, beginning usually on the third day after administration of alloxan. In all rats kept on

proportion of the surviving animals, showed signs of more or less intensive hemoglobinuria. The effect of dietary factors on this early mortality and hemoglobinuria following administration of alloxan is summarized in Table 1. The relationship of dietary factors to longer survival

TABLE 1
EFFECT OF DIETARY FACTORS ON EARLY MORTALITY AND HEMOGLOBINURIA
FOLLOWING ADMINISTRATION OF ALLOXAN

Diet	Casein	Sucrose	Fat	Cod-liver oil	Yeast	Salt mixture	No. of rats used	Rats dead in first two days		Hemoglobinuria (%)		
								No.	%	0	+	++
(1) High lard	20	36	38	2	..	4	20	11	55	0	33	66
(2) " " with tocopherol	20	36	38	2	..	4	20	5	25	100	0	0
(3) " " " yeast	20	31	38	2	5	4	10	0	0	50	20	30
(4) " " " " and tocopherol	20	31	38	2	5	4	10	0	0	100	0	0
(5) " " " methionine	20	36	38	2	..	4	20	10	50	6,6	6,6	86,6
(6) " " " yeast and methionine	20	31	38	2	5	4	10	2	20	20	40	40
(7) " " " choline	20	36	38	2	..	4	20	10	50	26,6	26,6	46,6
(8) " " " yeast and choline	20	31	38	2	5	4	10	1	10	70	10	20
(9) " vegetable shortening ("Vream")	20	36	38	2	..	4	20	2	10	100	0	0
(10) " "Vream" with yeast	20	31	38	2	5	4	10	2	20	100	0	0
(11) " coconut oil	20	36	38	2	..	4	20	12	60	13,3	6,6	80
(12) " " " with tocopherol	20	36	38	2	..	4	10	2	20	100	0	0
(13) " " " " yeast	20	31	38	2	5	4	10	0	0	80	0	20
(14) " " " " yeast and tocopherol	20	31	38	2	5	4	10	0	0	100	0	0
(15) " protein and high lard	40	16	38	2	..	4	20	15	75	6,6	13,3	80
(16) " " " " " with yeast	40	11	38	2	5	4	10	3	30	20	20	60
(17) Low fat	20	76	..	..	..	4	20	5	25	40	6,6	53,3
(18) " " with tocopherol	20	76	..	..	..	4	20	0	0	100	0	0
(19) " " " yeast	20	71	..	..	5	4	10	1	10	10	20	70
(20) " " " " and tocopherol	20	71	..	..	5	4	10	1	10	100	0	0

rations containing yeast, and in 15 out of 20 in each group of rats receiving the other rations, special attention was paid to hemoglobinuria by placing sheets of white filter paper underneath the bottom screens of the single cages and analyzing the urine obtained for the presence of hemoglobin. In several instances intravascular hemolysis was tested in the blood serum and by repeated red blood cell counts.

Rats often died within the first two days after administration of alloxan, and several of these, as well as a fair

and to diabetes, as well as the histological findings, will be discussed in a subsequent communication.

The multitude of data contained in Table 1 may be summarized as follows: The highest early mortality was observed in rats fed rations free from yeast and high in lard or in coconut oil. This result was not alleviated by supplements of methionine or choline or by a higher proportion of protein in the diet. In contrast, a statistically significant reduction of early mortality was achieved by supplementing the rations high in lard or in coconut oil

with tocopherol or by using rations with a vegetable shortening as the main source of fat. This vegetable shortening (Vream) is rich in tocopherol. An equally significant drop in the rate of early mortality was seen in rats receiving rations very low in fat. In general, rations containing yeast enabled rats to live longer—at least beyond the arbitrary two-day limit—than rats fed similar rations without yeast.

Hemoglobinuria was never observed in rats fed rations rich in tocopherol. On the other hand, a varying, but often high proportion of the experimental rats kept on rations free from, or very low in, tocopherol showed hemoglobinuria after intraperitoneal injection of alloxan. Here again, supplements of methionine or high protein-high lard diet were, in the absence of tocopherol, without any appreciable effect on hemoglobinuria. Supplements of choline, however, seemed to have a slight but definite beneficial effect on hemoglobinuria. Addition of yeast to the ration was followed in most instances by a reduction of hemoglobinuria. The yeast rations with high protein or with low fat were exceptions and did not decrease the incidence and intensity of hemoglobinuria.

Hemoglobinuria was accompanied by intravascular hemolysis and a rapid fall in the red blood cell count, occurring almost immediately, with a peak a few hours after injection of alloxan. Here are a few examples of the changes in red blood cell count:

Before alloxan	8.8, 7.4, 7.6, 8.5, 7.5, 7.5 million/mm ³
After “	1.9, 4.0, 1.0, 2.9, 1.7, 2.7 “ “

In the past only Kennedy and Lukens (7) mentioned hemolysis as a complication of diabetes in rabbits. They implied that hemolysis and diabetes are closely related. In our observations, early mortality and hemoglobinuria (hemolysis) occurred independently from diabetes. The dietary factors, such as tocopherol or yeast, or a ration low in fat, which in our experience reduced the rate of early mortality and hemoglobinuria, had no influence on the incidence and intensity of diabetes. Thus, the pharmacological-toxicological action of alloxan seems to be based on two independent components, one being responsible for the hemolysis, the other for the diabetes. The preventive effect of tocopherol and related dietary factors on hemolysis caused by alloxan requires further elucidation.

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Growth and Fruiting of Tomato Plants as Influenced by Growth-regulating Substances Applied to the Soil¹

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Hormones are used today for numerous purposes, including killing of weeds, thinning of blossoms, checking fruit drop, and increasing fruit set in various plants. Their application to flower clusters has been effective in increasing the fruit set of tomatoes during winter days of low light intensity in the north and also in hastening the maturity of the early summer crop. The addition of these growth regulators directly to the soil and their subsequent effect on the fruiting of plants does not seem to have received adequate attention. Zimmerman and Hitchcock (6) reported that “one to five mgms of 2,5-dichlorobenzoic acid per 4 inch pot of soil caused fruit set of flowers and buds present when the chemical was applied to the soil. It also caused parthenocarpic development of flower buds which were initiated after the soil was treated.”

The following preliminary experiments were conducted in late spring of 1948 in the greenhouse with a view to studying the effect of application of various hormones to the soil on the growth and fruiting of the tomato plant. Seed of Valiant variety of tomatoes was sown on January 16, 1948; the seedlings were transplanted in flats 2" x 2" apart. Vigorously growing, uniform plants were transferred to 12" pots on March 29. They were divided into 4 groups on April 16, when 2-3 flowers on the first cluster of most of the plants had opened. Aqueous solutions of hormones were applied as follows:

- Treatment No. 1— 50 ppm *o*-chlorophenoxyacetic acid, 100 cc thrice, at weekly intervals.
- “ No. 2— 50 ppm α -*o*-chlorophenoxypropionic acid, 100 cc thrice, at weekly intervals.
- “ No. 3—100 ppm 2,5-dichlorobenzoic acid, 100 cc twice, at weekly intervals.
- “ No. 4—Check.

The general appearance of the treated plants was not much affected except in the case of those treated with *o*-chlorophenoxyacetic acid. These were yellowish-green and comparatively weak, resembling plants infected with virus mosaic. Their top growth was significantly poorer than the ones treated with α -*o*-chlorophenoxypropionic acid and 2,5-dichlorobenzoic acid (Table 1).

Although there was no statistically significant difference between root weight of different groups of plants, the data tend to indicate that there was some stimulation of root growth in the case of plants treated with α -*o*-chlorophenoxypropionic acid.

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The average weight per fruit, harvested before July 1, for all hormone treatments taken together was 166 gm as compared with 93 for the check. This difference is

TABLE 1

TOP AND ROOT GROWTH OF PLANTS AS INFLUENCED BY DIFFERENT TREATMENTS (Mean per Plant)

Treatment No.	Tops (oz.) (fresh wt.)	Roots (gm) (dry wt.)
1	19.5	11.1
2	30.25	15.7
3	28.0	10.5
4 (check)	25.5	10.3

statistically significant. However, when the different hormone treatments are considered separately, it is found that only treatment No. 3 had significantly larger fruit size than the check. This seems to be due to high experimental errors because of 4 replications only. The weight of the fruits was decreased in the case of plants treated with α -o-chlorophenoxypropionic acid and 2,5-dichlorobenzoic acid after July 1 (Table 2).

TABLE 2

MEAN YIELD PER PLANT AND AVERAGE FRUIT WEIGHT UNDER DIFFERENT TREATMENTS (GM)

Treatment No.	Mean yield per plant	Fruit size up to July 1	Fruit size after July 1
1	1.489	147	157
2	1.592	154	104
3	1.669	196	133
4 (check)	1.549	93	101

The total yield of the plants did not seem to be influenced to any appreciable degree under these conditions.

The fruits harvested from different treatments were cut and tasted. Those treated with α -o-chlorophenoxypropionic acid and 2,5-dichlorobenzoic acid were rich red and more meaty than untreated ones. They were adjudged as sweeter and richer in flavor than the ones treated with o-chlorophenoxyacetic acid and check. However, there appeared in all the treated groups some fruits with a greenish jelly-like substance, which was not considered very desirable from the appearance point of view. There were no misshapen fruits or fruits with unfilled locules on treated plants, as are sometimes obtained when tomato blossoms are sprayed with hormones.

The first one or two fruits on each plant contained seeds, while those which matured after that were seedless. This indicates that flowers fertilized before the application of hormones to the soil developed seed and that growth in others was affected by the hormones. In these latter it may be that the pollen was rendered ineffective or that abnormal development of the ovules started before fertilization could take place. This parthenocarpic development of the fruits reveals that the hormones were absorbed by the roots and were transported through the stem to other aerial parts, (2, 3, 5).

As there were several buds on the first and second cluster at the time of application of hormones which developed into seedless fruits, it does not necessarily follow that only those buds initiated after application of hormones develop parthenocarpically, as has been suggested (6). The presence of seeds in the young fruits observed on July 5 shows that the hormones lost their effect within 7-8 weeks. It is possible that they were leached out of the soil, absorbed and fixed by soil colloids, or decomposed and thus rendered ineffective. This is further supported by the decrease in average fruit weight of plants treated with α -o-chlorophenoxypropionic acid and 2,5-dichlorobenzoic acid after July 1 (Table 2). DeRose (1) found 2,4-dichlorophenoxyacetic acid in leachate. Even when leaching was prevented, it was inactivated within 68-80 days, while 2,4,5-trichlorophenoxyacetic acid retained its effectiveness for a much longer period. However, Nutman, Thornton, and Quastel (4) reported that 2,4-dichlorophenoxyacetic acid, when applied to the soil, lost its toxicity within 3-6 days.

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Early Maturation of Calimyrna Fig Fruits by Means of Synthetic Hormone Sprays

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Maturation of Calimyrna fig fruits in approximately 60 days instead of the average 120-day period necessary for normal fruit development to maturity has been accomplished as a result of spraying unpollinated but pollen-receptive syconia with solutions of 2,4,5-trichlorophenoxyacetic acid. The fruits thus formed were comparable in size and color to mature, pollinated (caprifid) fruits. Although completely devoid of achenes ("seeds"), the hormone-produced fruits were well filled with pulp and quite palatable.

These results were obtained as part of a research program initiated in 1947 and aimed at developing a commercially feasible method of setting parthenocarpically the syconia of the Calimyrna fig, a variety that requires cross-pollination for fruit development to maturity (1). This preliminary work showed that a spray of indole butyric acid at 1,500 ppm was effective in setting parthenocarpic fruit. As a continuation of the program this season, a number of other synthetic auxins

were tried, among which were 2,4,5-trichlorophenoxyacetic acid and its isopropyl ester.

Both the acid form and the ester, in concentrations of 10, 25, 50, 75, and 100 ppm, were sprayed on fruits and foliage, using 5 branches/treatment. At the time of application each branch bore 5 figs, the oldest of which had been macroscopically evident for approximately 45 days. In 15 days the above concentrations of the acid had induced, respectively, 56%, 64%, 69%, 72%, and 65% mature fruits of average size. At the 10-ppm concentration there were 8 (32%) green, immature fruits, 1 (4%) at the 25 ppm concentration, and none at the other concentrations. Even the youngest fruits, although they did not attain full size, were yellow and soft. Comparable results were obtained with the isopropyl ester. Parallel treatments with 2,4-D failed to elicit this response.

At 10 ppm the 2,4,5-trichlorophenoxyacetic acid resulted in no injury or only a very mild leaf chlorosis. At higher concentrations, however, the injury became increasingly severe, and death of the treated branches occurred at the 75- and 100-ppm levels about 4 weeks after spraying. It is believed that the injurious effect of the treatment was accentuated because the branches were bagged for three weeks to exclude caprifying wasps. In some instances, unbagged branches adjacent to those sprayed received small quantities of spray as drift, and, although the fruit matured similarly to that fully treated, there was little or no injury, even at 100 ppm.

A similar acceleration of the ripening processes was found in 1947 following the injection of a solution of 1,500 ppm of indole butyric acid into the cavities of the receptive syconia (1). In this case, mature fruits were obtained 12 days after treatment, or 6 weeks previous to the normal maturity date. As far as the writers are aware, these are the first reported instances in which the normal developmental pattern of a fruit has been so radically accelerated.

Such a phenomenal speeding-up of fruit development is believed to be of considerable interest. It is a strong indication of the hormonal nature of fruit ripening. The 2,4,5-trichlorophenoxyacetic acid apparently raises the hormone level in the plant to such a high point that the mobilization in the fruit of the stored reserves is almost immediate, whereas, under the influence of the normal hormone level, the same process occurs much more slowly. The present finding, coupled with the work of van Overbeek on the hormone induction of flowering in the pineapple (2), indicates that the entire physiological mechanism of flower and fruit production is, at least in part, under the control of hormones.

These results further emphasize the high degree of specificity of the synthetic hormones and the responses they induce. 2,4-D, even at 100 ppm, was ineffective in hastening maturation, whereas the very closely related compound, 2,4,5-trichlorophenoxyacetic acid, was strikingly effective.

It is to be expected that this rapid mobilization of food reserves in response to hormone application would occur only in plants in which the reserves were large enough to

support the accelerated development. In those plants in which there is a clear correlation between leaf area and fruit size, the food supply might become the limiting factor rather than the hormone level. However, the fig is rather unique in many respects, and it may be that the above response is peculiar to the fig alone.

What aftereffects a treatment with 2,4,5-trichlorophenoxyacetic acid would have on the continued vigor of the fig tree is not known. If no major damage results, however, it seems logical to assume that following fruit maturation the leaves could replenish the depleted reserves, and the tree would be capable of repeating the process the next season.

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Electronic Mapping of the Activity of the Heart and the Brain¹

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The electrocardiograph and the electroencephalograph provide information concerning the activity of the heart and the brain. In recent years it has become quite common to compare the wave traces picked up at different points on the chest in studies of the heart and also those picked up at different points on the skull in studies of the brain. The present paper describes a new way of collecting and presenting such information which has been developed to assist the observer in distinguishing easily those items which are most significant in the melee of confusing data obtained by conventional electrocardiographic and electroencephalographic means. The new method involves an "area display,"² the development of which has been based upon considerations of perception selectivity.³

The conventional electrocardiograph or electroencephalograph shows the time variation of potential at a point on the surface of the body in the form of a wave trace, with time as abscissa and potential as ordinate. Except for the fact that there is no superposition of successive traces, this is similar to the so-called "type A" presentation used in radar systems. The method described

¹ This research has been supported in part by the Signal Corps, the Air Materiel Command, and ONR. The authors wish to thank Mr. Fred Rosebury for the construction of the election beam pickup tubes used in the early experiments and Messrs. R. M. Redheffer, T. Moreno, A. B. Macnee, and G. Duvall for serving as subjects for the heart displays.

² Now at Stromberg Carlson Telephone Mfg. Company, Rochester, New York.

³ The area display was originally proposed to the senior author by Dr. Douglas Goldman for the purpose of locating brain tumors and other pathological areas in the brain.

⁴ In this connection see the section on "Perception Selectivity" in the article, "Some Fundamental Considerations Concerning Noise Reduction and Range in Radar and Communication" (*Proc. I.R.E.*, May 1948).

herein results in a two-dimensional display of the distribution of potential over the surface of the chest or the skull. This display appears on the screen of a cathode-ray tube as a "map" of the area under investigation and is thus somewhat similar to the so-called "PPI" presentation used in radar. The brightness at a given position on the screen is proportional to the potential of the corresponding point on the chest or the skull.

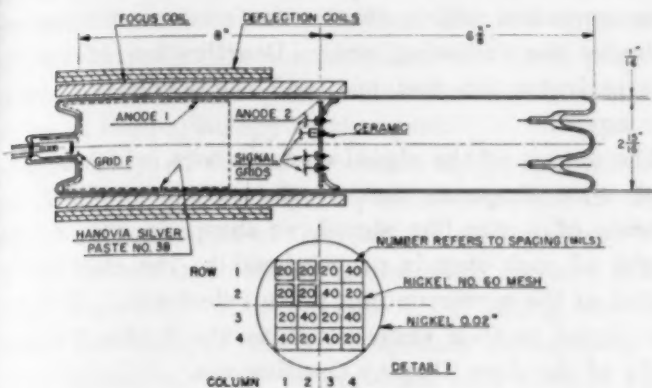


FIG. 1 First complete pickup tube for electronic potential mapping.

In order to obtain the area presentation, a pickup tube as shown in Fig. 1 was first used. Pickup electrodes are located at 16 individual grids in the tube. The locations of the electrodes on the chest correspond approximately to the locations of the grids to which they are connected. The array of 16 pickup grids is located in front of a single anode (called anode No. 2), and an electron beam is scanned across the grids. The potential on an individual grid regulates the amount of beam current to anode No. 2 at the time that the beam is passing through the grid in question. Consequently, if a standard type of cathode-ray tube with a phosphorescent screen is

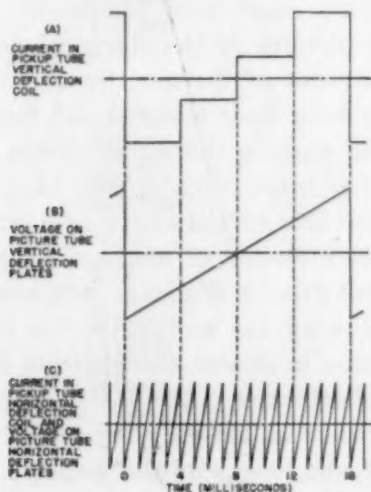


FIG. 2. Wave shapes of the scanning signals of the pickup and display tubes.

scanned in synchronism with the tube in Fig. 1, and if the signal current from anode No. 2, after suitable amplification, is applied to the intensity grid of the cathode-ray tube, the screen of this tube will show the approximate potential distribution across the chest.

The scanning signals used in this case are shown in Fig. 2. It will be noted that each horizontal line of grids

in the pickup tube is scanned four times before proceeding to the next line. At the same time, the vertical motion of the beam in the display tube is uniform. This method improves the area display, as illustrated in Fig. 3. Because of the spot size of the pickup tube, it was decided to scan the centers of the grids each time. This is the reason for the step-scanning signal in the pickup tube.

It was originally hoped that the system might be made to operate without amplifiers between the pickup electrodes and the signal grids of the pickup tube. This was not successful. The principal reason for difficulty was the spurious signal pattern which was introduced as the beam crossed over from one signal grid to another. A

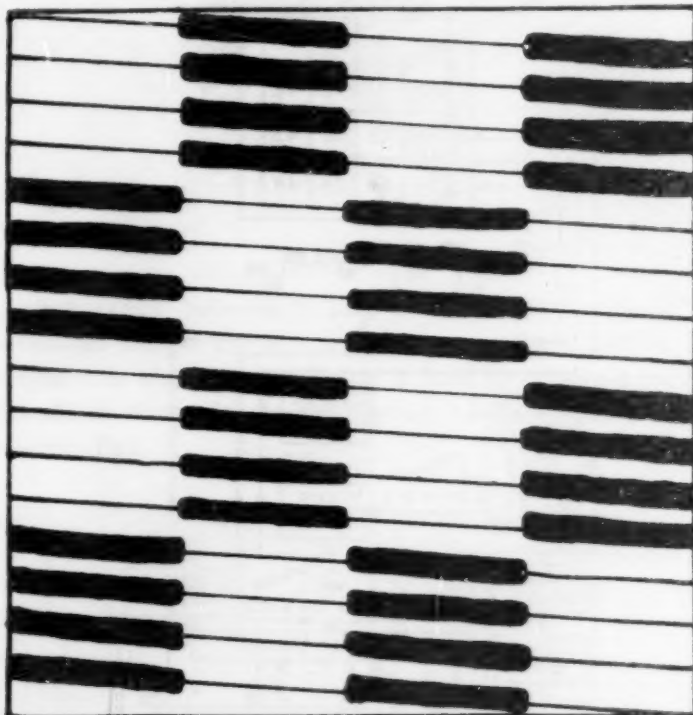


FIG. 3. Sketch of observed display pattern when signal grids of pickup tube are connected to d-c potentials arranged in a checkerboard pattern.

second pickup tube which used electrostatic focus and deflection and a high-voltage screen in front of the pickup grids gave a much finer spot size and generally improved performance, but still gave too much residual pattern.⁵ It was therefore decided to introduce amplifiers between the pickup electrodes and the signal grids to raise the desired signal to about a 1-v level at the grids. When this was done, the signal pattern was considerably stronger than the residual pattern, and a potential area display showing the activity of the heart could be seen on the screen.

These original displays of heart activity were not satisfactory for several reasons: (1) The spurious residual pattern was always present and could not conveniently be removed even with amplification of the desired signal; (2) the 16 different grids, although of apparently identical structure, were of widely different sensitivities, probably because of local work-function differences of the screen material; (3) there was interaction between

⁵ The details of this work will be given in a later paper to be submitted to the *Proceedings of the Institute of Radio Engineers*.

the different grids, presumably due to secondary electrons. It appears probable that these difficulties could be eliminated by suitable modifications in the pickup tube. In order to avoid the delays which would have been necessitated by extensive redesign and development of the pickup tube, however, it was decided to substitute an electronic circuit commutator for it in the later experiments.

The electronic circuit commutator has the same function as the pickup tube in the over-all system, but the details of its operation are completely different. A block diagram of the circuit is shown in Fig. 4. Instead of

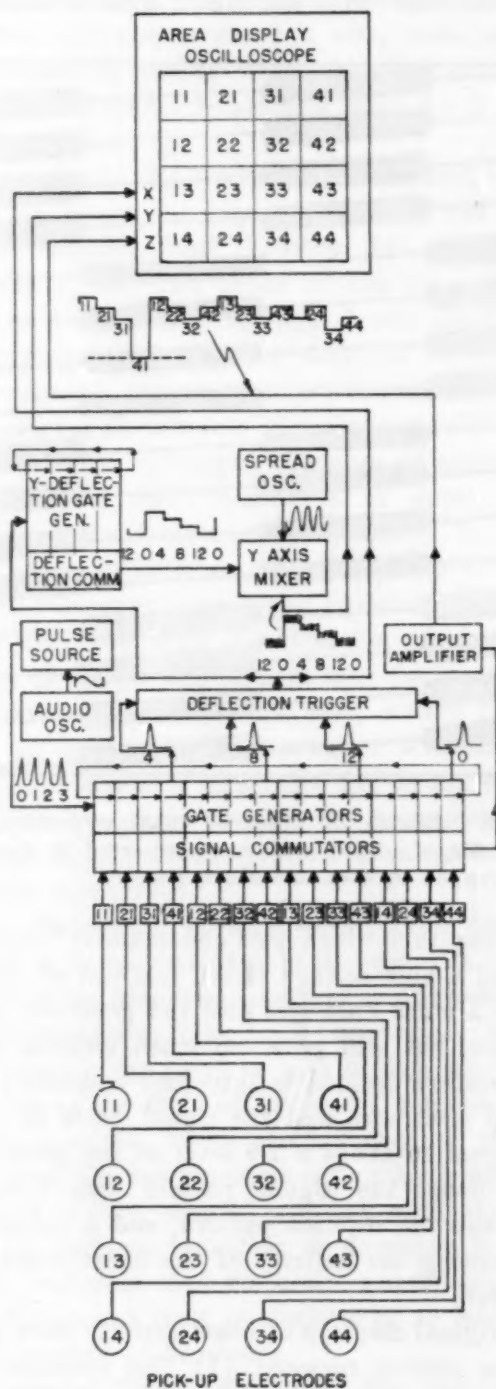


FIG. 4. Block diagram of the electronic circuit commutator system.

the 16 signal grids of Fig. 1, we now have 16 signal commutator units. Each of the 16 amplifiers whose inputs are connected to the 16 pickup electrodes is connected to a different one of the signal commutators in a definitely planned sequence, as shown in Fig. 4. When a commutator is activated, it amplifies the signal coming to it and

transfers it to the output amplifier. When a commutator unit is deactivated, it has no output. At any one time, only one commutator unit is activated and the other 15 are deactivated.

The commutator units are activated by the gate generators in the sequence shown in Fig. 4. These generators are synchronized by pulses derived from an audio oscillator; the latter is therefore the primary timing source. The generators also operate in sequence, and the same operation which deactivates one commutator unit activates the following one. Deactivation of the 16th unit activates the first one, and the sequence starts all over again.

The output of the signal commutators, which is of the same wave shape as that of the output amplifier, then consists of a step-like signal, as shown in Fig. 4. The height of each step is proportional to the electrical potential at the corresponding pickup electrode. This step-like signal is then transmitted to the Z-axis (intensity grid) of the Area Display Oscilloscope.

For reasons explained elsewhere,⁵ it is necessary to use one of the steps as a d-c reference level to prevent interaction between the other steps. The corresponding elementary square in the Area Scope is therefore inactive. We used elementary square 41 as the inactive reference element.

The sweep circuits of the oscilloscopes are synchronized by the same pulses which actuate the gate generators (Fig. 4). In order to fill in the areas of the elementary squares in the Area Scope, a high-frequency sine wave is superimposed on the Y-axis deflection voltage. This takes the place of the fourfold scanning of the elementary squares shown in Fig. 3 and used in the earlier system when a pickup scanning tube was used.

With the use of the electronic circuit commutator excellent displays of the area distribution of potential on the surface of the chest were obtained. These show striking moving pictures of the electrical activity of the heart. The activities of the auricles and ventricles are distinguished by both their location and timing, and the movement of the exciting potential across the heart is clearly seen. It is interesting to note that, immediately after exercise, the size of the active area on the chest is increased and the direction of motion of the exciting potential is changed from a diagonal to a more horizontal direction. Following the motion of the excitation potential is a motion in almost the opposite direction, but somewhat more horizontal. The latter activity has been tentatively identified as the recovery period of the heart by cardiologists who have seen the displays.

Motion pictures have been taken of the area displays with a 16-mm camera. Prints of 16 consecutive pictures of the reel covering a total period of $1\frac{1}{15}$ sec are shown in Fig. 5. These pictures show slightly more than one complete period of the heart's activity (the subject had a pulse rate of 68/min). The locations of the pickup electrodes are shown in Fig. 6. The left forearm was used as an indifferent electrode.

While photographs such as those shown in Fig. 5 should give valuable information, particularly if the number of

frames per second is increased, it is very difficult, if not impossible, to synthesize the movements of the potentials across the chest from a study of a set of these photographs. However, the original reel from which the photographs came, when projected as a motion picture, shows the movements almost as clearly as direct observation of the screen of the cathode-ray tube. These movements are the most striking characteristic of the display.

Arrangements are being made with cardiologists for correlation between clinical findings and the appearance of the displays, and it is anticipated that these area displays will be useful both in clinical studies and in investigations of the physiology of the heart.

Area displays of the instantaneous skull potentials were also obtained. As anticipated, these could not be interpreted readily because of the speed of the activity. Special apparatus for obtaining useful skull displays is now being completed. This consists of a tuning unit and rectifier for each of the 16 amplifiers attached to the pickup electrodes. The tuning units have a band width of about 1 cycle/sec. The units are all tuned to the same frequency at any one setting, and the output of each unit is rectified and transmitted to the commutator. This provides a "spectroheliograph" type of display in which the area distribution of the rms potential at the tuning frequency will be shown. It is anticipated that such displays will be significant. The units are also arranged so

about 100 cycles and has a pass-band approximately 1 cycle wide in this range. All 16 tuning units in the respective channels are preset at the same frequency. In this way the 16 channels can be tuned through the fre-

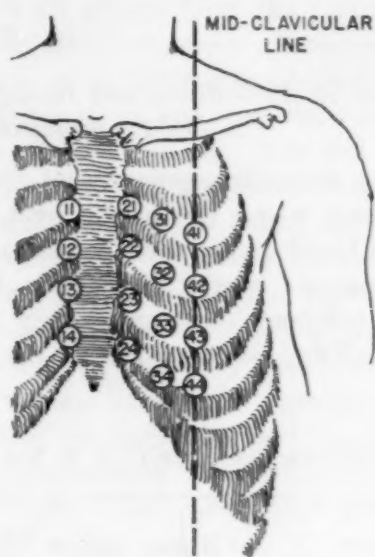


FIG. 6.

quency range between 0 and 50 cycles by varying the oscillator frequency through the range from 100 to 150 cycles. If the same oscillator is used to supply a carrier for all 16 channels, the tuning can be done with a single control dial.

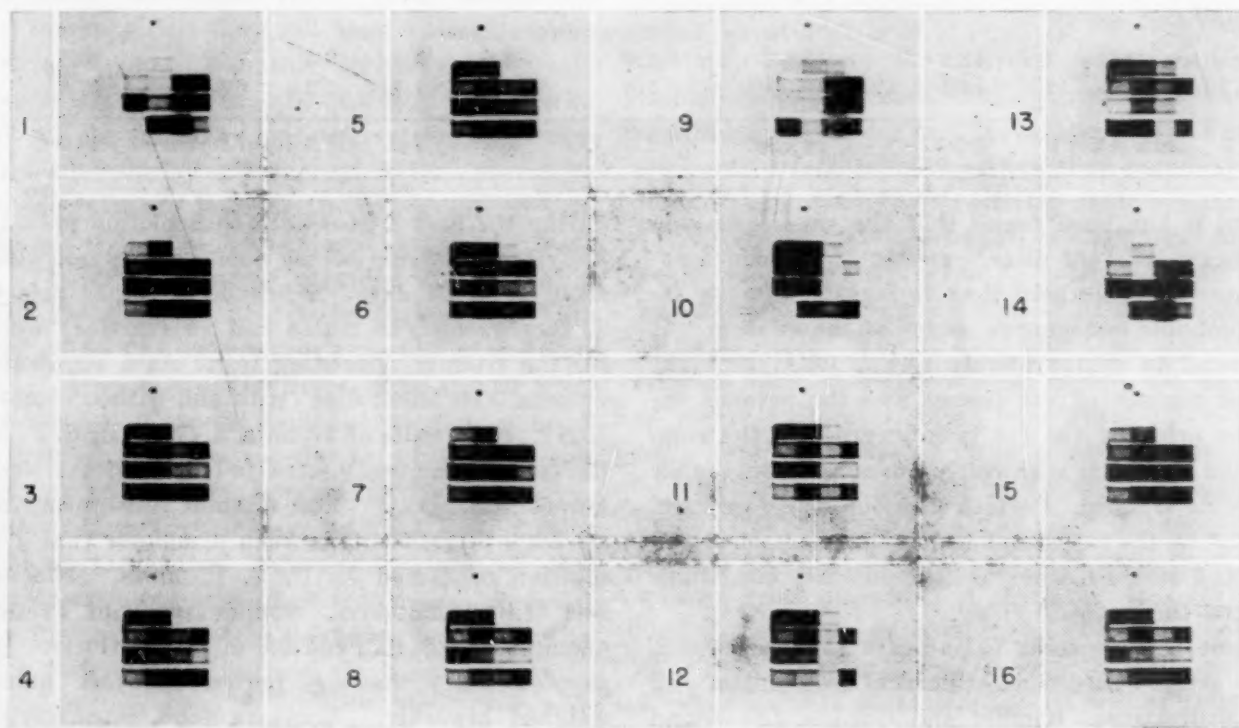


FIG. 5. Sixteen consecutive frames from a motion picture reel of the heart's activity (approximately 13 frames/heart beat).

that the rectified signal of the entire frequency band (without tuning), i.e. the envelope, can also be displayed.

Provision is made for tuning through the frequency range from 1 to 50 cycles by a superheterodyne method. The signal picked up is heterodyned in a mixer tube with an oscillator signal which has an adjustable frequency between 100 and 150 cycles. The output of the mixer enters the tuning unit, which is preset at a frequency of

One possible extension of the method is the taking of motion-picture photographs of the direct instantaneous displays and their subsequent observation in slow motion. Another possible extension is the use of a "stroboscopic" type of display, in which the frame frequency (frequency of scanning an entire picture) is continuously varied from 1 to 100/sec. This should select the activity which occurs near the frame frequency or its harmonics.

Does the U. S. P. Vitamin A-deficient Diet Require Supplementation With Ascorbic Acid?

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It has been generally assumed that the rat does not require a dietary source of ascorbic acid. This assumption has been based on the fact that the rat does not develop the symptoms usually considered characteristic of ascorbic acid deficiency in the guinea pig when subsisting on diets definitely scorbutogenic to the latter animal.

technic, are actual measures of vitamin A potency or whether the data are vitiated by the complications arising from concomitant ascorbic acid deficiency. Since the question merited consideration, the following study was undertaken.

Eighty young rats from our breeding colony, ranging in age from 21 to 24 days, were placed in individual metal cages and fed liberal allowances of the U. S. P. vitamin A-deficient diet. One-half of the young rats received the unsupplemented vitamin A-deficient diet; the other half, the deficient diet after it had been enriched with ascorbic acid at the rate of 5 gm of the crystalline vitamin to 1 kg of the ration. The ascorbic acid was incorporated into the ration just before the ration was allocated to the test animals. Each rat was weighed at weekly intervals.

TABLE 1

EFFECT OF SUPPLEMENTING THE U. S. P. VITAMIN A-DEFICIENT DIET WITH ASCORBIC ACID ON THE RESPONSE OF YOUNG RATS

Sex of test animals	No. of animals used	Avg. initial wt. (gm)	Wt. at end of depletion period (gm)	Avg. amount of vitamin A fed daily (U.S.P. units)	Avg. gain in wt. during :				Total gain in wt. (gm)	Standard deviation
					week 1 (gm)	week 2 (gm)	week 3 (gm)	week 4 (gm)		
<i>U. S. P. Vitamin A-deficient Diet</i>										
Males	16	44.2	133.8	1.5	7.6	6.9	9.5	6.4	30.4	6.8
Females	16	44.0	122.6	1.5	6.7	8.3	7.4	6.1	29.1	7.3
Avg.	both sexes	44.1	128.2	1.5	7.2	7.6	8.5	6.3	29.8	7.1
<i>U. S. P. Vitamin A-deficient Diet + Ascorbic Acid</i>										
Males	16	43.8	133.3	1.5	6.9	6.8	9.3	7.1	30.1	7.5
Females	16	44.1	123.9	1.5	6.1	7.5	7.2	6.8	27.6	6.3
Avg.	both sexes	44.0	128.6	1.5	6.5	7.2	8.2	7.0	28.9	6.9

Furthermore, it has been found that the rat, while subsisting on many different diets, excretes in its urine considerably more ascorbic acid than it ingests, thereby indicating a probable endogenous source of the vitamin. It has been found in comparatively recent years that the ascorbic acid content of rat tissues and the amount excreted in the urine of the rat is influenced by the composition of the rat's diet with respect to constituents other than the specific vitamin. Certain compounds like carvone, when ingested by the rat, result in increased ascorbic acid production and storage, whereas other dietary conditions have produced the opposite effect.

More recent reports seem to indicate that perhaps a relationship exists between ascorbic acid metabolism and vitamin A utilization. Kimble and Gordon (2) found that ascorbic acid therapy resulted in increased vitamin A blood levels in human subjects without an increase in vitamin A intake. Since this was published, other investigators have reported abnormally low blood and tissue levels of ascorbic acid associated with vitamin A deficiency in the rat. Among these latter reports are that of Jonsen, Obel, and Sjoberg (1) and the more recent reports of Mayer and Krehl (3).

These observations seem to raise the question as to whether the data obtained by means of the usual biological assay for vitamin A, such as with the official U. S. P.

during the first 3 weeks of the depletion period and then daily until the end of the depletion period, which ranged from 28 to 34 days. When depleted, 32 rats from each dietary group (16 males and 16 females) were selected for the vitamin A feeding test. As a supplement to the vitamin A-deficient diet (with and without ascorbic acid), 10.5 U. S. P. units of vitamin A (New U. S. P. Vitamin A Reference Standard) were fed to each rat weekly for a 4-week test period. The vitamin A supplement was dissolved in Wesson oil in such a manner that 1 ml of the solution contained 15 U. S. P. units. The supplement was fed on Mondays, Wednesdays, and Fridays in the amounts of 0.2, 0.2, and 0.3 ml, respectively. During the supplementary feeding period all test animals were weighed biweekly. Accurate food consumption records were kept at all times and the animals were examined frequently for external symptoms of abnormal physical conditions.

A summary of some of the results obtained is presented in Table 1. From these data it is apparent that no improved growth response, during either the depletion period or the subsequent vitamin A feeding period, resulted from supplementing the basal diet with crystalline ascorbic acid. Furthermore, examination of the test animals did not reveal that the ascorbic acid-fed rats were superior physically to those receiving the regular U. S. P.

vitamin A-deficient diet. The data indicate that no improvement in the results obtained in the usual biological assay for vitamin A was achieved by supplementing the basal diet with crystalline ascorbic acid. Somewhat different results might have been obtained, however, had the B-vitamins been furnished in the crystalline form, as in the studies of Mayer and Krehl (3), instead of in the form of dried brewers' yeast, as in this study.

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The Effectiveness of Carbarsone in Rendering Young Mice Free of Intestinal Protozoa

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Carbarsone (*p*-carbamino-phenyl-arsonic acid) was used in an attempt to eradicate the intestinal protozoa of young mice needed for other work. These results are presented in the hope that they will be of value to others who are relying upon this arsenic derivative to obtain amoeba-free animals prior to infection with *Endamoeba histolytica*. All the mice used here were raised and maintained on an adequate diet prepared in the laboratory (4). Care was taken in the preparation of this diet to prevent contamination, and it was stored in a deep freezer until used. The drinking water provided was sterilized. The doses of the chemical used were suggested by the work of Reed, *et al.* (5) on monkeys and rabbits and that of Gabaldon (2) on rats. The doses, dissolved in alkaline aqueous solution, were forced into the stomach through a blunted, 18-gauge needle attached to a 1-cc tuberculin syringe. The cages containing the mice undergoing treatment were kept in a fume hood located in a room outside of the animal quarters. Before use, the hood was disinfected and made dust free by use of an air filter. In a further attempt to minimize the possibility of reinfection from outside sources, all cages were sterilized just prior to their use.

In the first experiment, 60 mice, 6 weeks old, were selected. These were divided according to sex into 6 treatment groups of 10 mice each. Each group was confined in a separate cage and after overnight fasting was given 1 through 6 mg of carbarsone daily, respectively, for 10 consecutive days. The average weight of the mice was 20 gm, so that the dosage for those given 1 mg was at the rate of 50 mg/kg (5). No mice were lost during treatment, and there were no visible signs of toxicity. A

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7th group of 10 mice of the same age was included as untreated controls. These were not confined to the fume hood but were fed the same diet and were fasted for the same periods as the treated mice. As expected, there was loss of weight in all groups from the fasting, but this was regained soon after treatment. At intervals following treatment, one mouse from each of the 7 groups was sacrificed to determine, by repeated cecal examinations, the effectiveness of the treatment. The first checks were made 4 days post-treatment, and thereafter checks were made at 2-day intervals. In all cases, the control mice showed large numbers of flagellates, including *Giardia muris* (3) in about one-half, and 8 of the 10 had infections with an amoeba tentatively designated as *E. muris*. Of the mice given 1-, 2-, and 3-mg treatments of carbarsone, respectively, those killed 4-10 days after treatment showed no amoebae, but flagellates were found in decreasing numbers correlated with the increasing doses. The remainder of the mice, killed 12-22 days post-treatment, showed flagellates and/or amoebae. It was thus clear that carbarsone in these doses was not effective.

In the second experiment, the dosage of carbarsone was increased according to the recommendation of Gabaldon (2). Mice of the same age as above were divided according to sex into 3 groups of 10 each and received, after overnight fasting, 10, 20, and 30 mg, respectively, for 5 days. Three mice of the group treated with 20 mg and one of the group treated with 30 mg died soon after treatment. These deaths probably resulted from toxicity, but diarrhea and the nervous symptoms ascribed by Gabaldon (1) to such toxicity were not observed. It should be pointed out that the largest dosage used here (30 mg) was considerably less than that found by Gabaldon to be the minimal dose producing toxic symptoms in rats (4,000 mg/kg of body weight, or equivalent to 80 mg/20 gm of body weight). The 10 untreated controls showed about the same rate and intensity of protozoan infections as those above. For 20 days post-treatment, none of the treated mice showed protozoa, except for an occasional *G. muris*. However, those mice killed 22 or more days after treatment showed large numbers of *E. muris*.

While it is not possible to exclude reinfection by airborne amoebae cysts from wild mice, this seems extremely unlikely in view of the precautions mentioned above. It appears from these results, therefore, that carbarsone, as used, exerted an amoebastatic effect but did not eradicate *E. muris*. This could lead to error in interpreting results of experimental *E. histolytica* infections following such carbarsone treatment, since the active, unstained trophozoites of the two amoebae are quite similar in certain morphological details and in type of motility.

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Obituary

William Delbert Funkhouser

1881-1948

William D. Funkhouser, whose death occurred at Lexington, Kentucky, on June 9, was born in Rockport, Indiana, March 13, 1881. He was educated in Indianapolis public schools and was graduated from Wabash College with honors in 1905. In college he was a star athlete and participated in most campus activities, yet had an almost perfect scholastic standing.

After teaching in high schools in Brazil, Indiana, and while teaching in Ithaca, New York, he attended Cornell University, where he earned the M.A. degree in 1912 and the Ph.D. in 1916.

His Master's thesis, "Homologies of the Wing-Veins of the Membracidae," was a contribution valuable not only for its biological implications, but also as a tool for taxonomy on that form. His doctoral dissertation, "Biology of the Membracidae of the Cayuga Lake Basin," followed in 1916, but not before the publication of a number of taxonomic papers.

In 1918 he was appointed professor of zoology and head of the Department at the University of Kentucky and retained this position until his death. During those years he was a prodigious worker in the field of his specialty, often writing from 15 to 20 papers per year in this alone. In a short time he had become the principal authority on the taxonomy of the Membracidae. Seldom a week passed when the mails or express failed to bring parcels of these insects for determination. As often as not they had been collected in the remotest nooks of the earth's surface. Often cited as his most thrilling experience was the discovery that a package from the British Museum in 1941 contained membracids collected in South America by Charles Darwin while on the famous voyage of the *Beagle*, over a hundred years ago. Aside from the number of species and genera named by him, the best-known single work in his specialty is the 573-page *Catalog of the Membracidae* (1927).

In Kentucky Dr. Funkhouser saw the wealth of opportunity in the opening and analysis of Indian mounds. With his friend and colleague, W. S. Webb, he spent his vacations in the field, exploring and excavating, often doing much of the pick-and-shovel work which remained after the mounds were sliced. His systematic training and nature were apparent here

just as they were in taxonomy. The excavations were usually works of art. This endeavor brought forth a new flow of literature in the University of Kentucky Reports in Anthropology and Archaeology, as well as his *Ancient life in Kentucky* (1926). The Department of Anthropology and Archaeology at the University, in which he became and remained a professor, is also a direct outgrowth of the joint efforts of Funkhouser and Webb.

While archaeological exploration was his recreation it also afforded him opportunity to observe the distribution of animal life. His own observations and verified records obtained from inhabitants provided him with the material for his *Wild life in Kentucky* (1924).

Increasing administrative duties pertaining to the Graduate School, of which he was dean from 1925, encroached on his field work and soon compelled him to forego that avocation.

On a trip around the world in 1932-33, during which he made the personal acquaintance of those with whom he had previously had only professional correspondence, side excursions were made into Malayan and African jungles to collect membracids and to observe the animal life with which the jungles are associated. Reels of motion pictures which he made showing human types provided illustrative material for ethnology courses after his return.

With all of Dr. Funkhouser's professional achievements, his 327 publications, numerous honors, memberships and offices in learned societies, a life sketch would be incomplete without mention of the qualities which endeared him to his colleagues, acquaintances, and thousands of students of two generations. These were his personal charm and his ability to portray vividly and lucidly his delightfully informal and intensely interesting lectures and conversations. He was indeed a teacher with few peers.

The last year of his life became increasingly difficult because of the subversive nature of his ailment, bronchogenic carcinoma, which resulted in his death. His last hours were gladdened in an unusual way in that this day had been chosen for a bedside preview of a Giesbert portrait under preparation for presentation to the University by a group of his friends.

ALFRED BRAUER

University of Kentucky

Book Reviews

Advances in biological and medical physics. (Vol. I.) John H. Lawrence and J. G. Hamilton. (Eds.) New York: Academic Press, 1948. Pp. xi+484. \$8.60.

In a rapidly widening biological field the use of physics either directly or by implication is essential. Effective entry into this field can be made only by surmounting several difficulties, one of the worst being the scattered nature of the literature needed for study before work is begun. The advent of a series comparable to *Advances in enzymology* is therefore of great importance and undoubtedly will greatly further the development of the new field of biophysics.

The present volume contains a series of authoritative articles centered around radioactivity and isotopic tracers, both radioactive and stable. For the first time a collection of reviews of work on nitrogen, carbon, iron, phosphorus, and iodine metabolism, written by such authorities as Vennesland, Hahn, Chaikoff, Zilversmit, and Leblond, is available. In addition, a highly significant discussion of nucleic acid metabolism by Hevesy is included. These articles form the unique and essential part of the volume. Very valuable reviews on the general use of isotopes in medicine, the nature of artificial radioactivity, radioactive instrumentation, and health physics by Dougherty and Lawrence, Cohn, Evans, and Parker supplement the accounts of actual research advances. In addition, an interesting article by Howland and Stafford Warren on the effects of atom-bomb irradiation is included. There is no doubt at all of the great importance and value of the volume.

There arises the question as to the future of the series. Apparently it is to be primarily concerned with the application of nuclear physics to biology. While this is undoubtedly of high importance, it is to be hoped that other significant developments such as the use of X-rays in elucidating biomolecular structure, action potential measurement in nerve fibers, or ultraviolet and electron microscopy will be included. Finally, a word in favor of interpretative biophysics such as has been attempted by Lea should be added.

The editors and publishers are to be congratulated on initiating a series in a new field of such high interest.

ERNEST C. POLLARD

Yale University

Limnological methods. Paul S. Welch. Philadelphia-Toronto: Blakiston, 1948. Pp. xviii+381. (Illustrated.) \$7.00.

The past 35 years have seen the rapid expansion of limnology, and although many field and laboratory procedures are peculiar to this science, some have been modified or borrowed from geographers, chemists, physicists, and oceanographers. It is a pleasure to see that these

procedures, heretofore widely scattered throughout the literature, are now available in one volume. *Limnological methods* is not encyclopedic; it includes only those selected and standard methods considered necessary for (1) an introduction to the subject matter of limnology, (2) lake and stream surveys, and (3) the furtherance of more specialized research.

A large portion of the book deals with mapping procedures. Physical methods include turbidity and color measurements, various types of thermometers, determination of water movements and light penetration, and descriptions of bottom samplers. Selected chemical methods include dissolved oxygen, alkalinity, hydrogen-ion concentration, and specific conductance. A variety of plankton nets, traps, centrifuges, and filters are discussed and their comparative usefulness for quantitative work evaluated. Plankton counting methods are compared. Qualitative and quantitative apparatus for bottom fauna and rooted aquatic plants are also considered.

Each technique and piece of apparatus and its uses are described in logical order, so that even an inexperienced worker can, by following the itemized directions, do an effective piece of field or laboratory work. It is gratifying to note that both the advantages and disadvantages of the different procedures are stressed.

An Appendix contains useful tables, hints on the proper care of ropes, and short descriptions of accessory equipment. It is regrettable that the book does not contain a list of firms and supply houses from which specialized limnological equipment may be purchased.

Although its price is unusually high for a volume of this size, *Limnological methods* is an essential reference for limnology courses and all lake and stream biologists, both theoretical and applied.

ROBERT W. PENNAK

University of Colorado

Modern operational calculus with applications in technical mathematics. N. W. McLachlan. Cambridge, Engl.: at the Univ. Press; New York: Macmillan, 1948. Pp. xiv+218. (Illustrated.) \$5.00.

Here is an advanced textbook on operational methods written primarily for postgraduate engineers and technologists. The author has a London doctorate in engineering and has written well-liked engineering textbooks on Bessel functions, Mathieu functions, complex variable, etc.

Like most writers on advanced operational methods, the author bases his methods solely on the Laplace transform. The transform is defined and operational rules are carefully derived, including four results announced as new. The methods are then applied to linear ordinary and partial differential equations with constant coefficients. The next portion of the book is devoted to the evaluation of integrals and the derivation of particular Laplace trans-

forms. There is a mathematical appendix followed by exercises for the reader, with answers where required. The book is completed with a table of 81 Laplace transforms, a few references, and a list of symbols; there is an adequate index.

The mathematical reader will be pleasantly surprised at the standards of mathematical understanding and rigor which the author intends the engineering reader to meet. In the Preface rigorous mathematics is likened to a precision limit-gauge which will eliminate trial-and-error fitting of machined components. This is usable propaganda for any who teach mathematics to engineers.

In addition to the attitude toward mathematical rigor, the book has numerous other good points. There are, for example, common-sense explanations of many matters of real-function theory not usually explained to engineers, such as the various types of discontinuities of a function. The p -multiplied form of the Laplace transform is used and should prove popular with engineers because of its dimensions and analogy to Heaviside's notation. The many mathematical examples, technical applications, and excellent graphs will be appreciated.

There are drawbacks, however. Appendices II and III show the author's knowledge of limit, uniform convergence, and improper integrals to be loose at best. Whether he is actually wrong in certain statements or whether they are merely ambiguous does not matter; in either case he is not teaching the reader the precision of thought which was set forth earlier as necessary in this field. One wonders whether the lack of precision may affect the accuracy of the principal part of the text; the reviewer found no error, however, in the proofs that were checked. Because the mathematical material is condensed and is presented unsystematically, it would seem best for the reader to learn the necessary real-function theory elsewhere. As with some similar books, the reader is unfortunately not told how far the operational calculus can be rigorously founded without use of the Laplace transform.

The book is recommended for collateral reading to those engineers with some knowledge of the field who want to go deeply into the engineering uses of the Laplace transform. Other textbooks, however, offer much better expositions of the subject to the uninitiated.

GEORGE E. FORSYTHE

National Bureau of Standards,
Los Angeles

An introduction to color. Ralph M. Evans. New York: John Wiley; London: Chapman & Hall, 1948. Pp. x + 339. (Illustrated.) \$6.00.

Since Newton's experiment on the production of colors by refraction in 1704, there have been perhaps 35 comprehensive treatments of the psychophysics of color. Since Evans' volume is the first important general book since the *Handbuch der normalen und pathologischen Physiologie* in 1929 (excluding the *Report of the Committee on Colorimetry*), it thus has the benefit of the standards adopted by the International Commission on Illumination in 1931, as well as the enormous amount of

theoretical and experimental literature which has since appeared.

Ralph M. Evans, head of the Color Control Department of Eastman Kodak, is a physicist by training but has a deeper interest in the psychological effects of color than most psychologists. He is known in the field chiefly for his contributions concerning visual processes and color photography and for work on brightness constancy in photographic reproductions. Mr. Evans has obtained a great deal of fame because of the remarkable slide lectures which he has been delivering to the technical societies during the last few years. These lectures are incomparable, being illustrated by a series of slides which could only be the result of his keen organization and the tremendous resources of the Eastman Kodak Company. This volume is a direct outgrowth of these lectures.

Unfortunately, the cost of color reproduction is so high that only 15 full-color, full-page plates could be included in this work. The color reproduction is even a bit as good as the other two major attempts to reproduce psychological color phenomena: the *Three monographs of color* published by the International Printing Ink Corporation in 1935, and the article on color which appeared in the July 3, 1944, issue of *Life*. Since the number of illustrations in the book is very small compared to the number included in the lectures, the latter have a comprehensiveness that the book does not.

It is Mr. Evans' intent to use, for the purposes of exposition, no mathematics higher than those taught in high school. Since modern color theory has its setting deep in the principles of projective geometry, this is a serious restriction to have imposed upon himself. To develop his theory with minor mathematics, Evans relies extensively on spectrophotometric curves, and the book abounds with examples. Since psychophysical color must always begin with the spectrophotometric curve, however, the completeness of treatment is most commendable. Evans, too, successfully develops the I. C. I. chromaticity plane under his imposed restriction, and his explanation of the projective relationships between colors on the plane is exceedingly well done. This is probably the only well rounded discussion at this level of difficulty in the literature.

Evans is at his best, however, when he discusses psychological phenomena. Included in the text are depth perception and illusion which do not really belong to the psychophysics of color, but after the splendid illustrations which are the specialty of Mr. Evans, one can only be glad that they are here made available. The illustrations throughout have a touch of glamour. Other texts have used square blocks to illustrate simultaneous color contrast, but Evans graphically and dramatically illustrates his point by using a blue Aladdin's lamp on different colored backgrounds.

Even in an introductory book there should perhaps be some discussion of color theory. The concept of a "fundamental sensation curve" relative to some of the better known theories would probably be of help to a beginning student.

Then, too, there are discussions of matters which need not have been included in an elementary text. For ex-

ample, there is quite a long piece on Beer's law series. As the concentration of a dye is changed, the transmission curve changes according to Beer's law. For every curve there is a point on the chromaticity plane, and thus the locus of such points is determined. This is work about which not too much is known practically, and probably for this reason, it was necessary that Evans use curves of hypothetical dyes. It is suggested here that dyes used in actual practice would not in general give a locus of the sharp curvature indicated by him. The binding and typography of the book are masterful. Certainly, this is a definitive volume. It is a pleasure to conclude with the statement that this is the greatest book on color since Helmholtz.

JOZEF COHEN

University of Illinois

Scientific Book Register

- BROWN, R. CHRISTIE. *Reproduction and survival*. London: Edward Arnold, 1948. Pp. 108. \$2.25.
- CHAMBERLAIN, ROBERT S. *The conquest and colonization of Yucatan, 1517-1550*. (Publ. 582). Washington, D. C.: Carnegie Institution of Washington, 1948. Pp. vii + 365. (Illustrated.) \$4.75, paper; \$5.50, cloth.
- CLEVENGER, EMMA I. *Principles governing eye operating room procedures*. St. Louis, Mo.: C. V. Mosby, 1948. Pp. 215. (Illustrated.) \$5.50.
- DAWSON, HELEN L. (Rev.) *Lambert's histology: an introduction and guide*. (2nd ed.) Philadelphia-Toronto: Blakiston, 1948. Pp. ix + 696. (Illustrated.) \$6.00.
- EGEL, PAULA F. *Technique of treatment for the cerebral palsy child*. St. Louis, Mo.: C. V. Mosby, 1948. Pp. 203. (Illustrated.) \$3.50.
- FREY-WYSSLING, A. *Submicroscopic morphology of protoplasm and its derivatives*. New York-London: Elsevier, 1948. Pp. viii + 255. (Illustrated.) \$6.00.
- HELLMAYR, CHARLES E., and CONOVER, BOARDMAN. *Catalogue of birds of the Americas and the adjacent islands in Field Museum of Natural History*. (Zoological Series, Vol. XIII, Part I, No. 2.) Chicago: Field Museum of Natural History, 1948. Pp. vii + 434. \$4.00.
- HOFFBAUER, F. W. (Ed.) *Liver injury: Transactions of the Seventh Conference, January 15 and 16, 1948*. New York, N. Y. New York: Josiah Macy, Jr. Foundation, 1948. Pp. 95. \$1.50.
- KRAUSKOPF, KONRAD BATES. *Fundamentals of physical science: an introduction to the physical sciences*. (2nd ed.) New York-London: McGraw-Hill, 1948. Pp. xii + 676. (Illustrated.) \$4.50.
- MEANS, J. H. *The thyroid and its diseases*. (2nd ed.) Philadelphia-London: J. B. Lippincott, 1948. Pp. xviii + 571. (Illustrated.)
- SALVADORI, MARIO G. *The mathematical solution of engineering problems*. New York-London: McGraw-Hill, 1948. Pp. x + 245. \$3.50.

THOMPSON, WARREN S. *Plenty of people: the world's population pressures, problems, and policies, and how they concern us*. (Rev. ed.) New York: Ronald Press, 1948. Pp. xiv + 281. (Illustrated.) \$3.50.

TRIPPENSEE, REUBEN EDWIN. *Wildlife management: upland game and general principles*. New York-London: McGraw-Hill, 1948. Pp. x + 479. (Illustrated.) \$5.00.

———. *Primera reunion Interamericana del tifo*. Mexico: Estados Unidos Mexicanos and Instituto de Asuntos Interamericanos, 1947. Pp. 459. (Illustrated.)

Just Received—

- ALEXANDER, FRANZ. *Fundamentals of psychoanalysis*. New York: W. W. Norton, 1948. Pp. 312. \$3.75.
- CROWTHER, J. G., and WHIDDINGTON, R. *Science at war*. New York: Philosophical Library, 1948. Pp. iv + 185. (Illustrated.) \$6.00.
- HECTOR, L. GRANT, LEIN, HERBERT S., and SCOUTEN, CLIFFORD E. *Physics for arts & sciences*. Philadelphia-Toronto: Blakiston, 1948. Pp. viii + 731. (Illustrated.) \$5.50.
- HEWITT, RICHARD M., et al. (Eds.) *Collected papers of the Mayo Clinic and the Mayo Foundation*. (Vol. XXXIX, 1947.) Philadelphia-London: W. B. Saunders, 1948. Pp. x + 871. (Illustrated.) \$12.50.
- MORRIS, PERCY A. *Boy's book of snakes: how to recognize and understand them*. New York: Ronald Press, 1948. Pp. viii + 185. (Illustrated.) \$3.00.
- KITCHEN, HERMINIE BROEDEL. (Ed.) *Diagnostic techniques for soils and crops: their value and use in estimating the fertility status of soils and nutritional requirements of crops*. Washington, D. C.: American Potash Institute, 1948. Pp. xxiii + 308. (Illustrated.) \$2.00.
- SANDERSON, ROBERT THOMAS. *Vacuum manipulation of volatile compounds: a laboratory manual describing the application of high vacuum technique in experimental chemistry*. New York: John Wiley; London: Chapman & Hall, 1948. Pp. viii + 162. (Illustrated.) \$3.00.
- SMITH, F. G. WALTON. *Atlantic reef corals: a handbook of the common reef and shallow-water corals of Bermuda, Florida, the West Indies and Brazil*. Miami, Fla.: Univ. Miami Press, 1948. Pp. 112. (Illustrated.) \$3.75.
- WAKSMAN, SELMAN A. *The literature of streptomycin, 1944-1948*. New Brunswick, N. J.: Rutgers Univ. Press, 1948. Pp. xv + 112.
- WILLIAMS, R. T. (Ed.) *The biochemical reactions of chemical warfare agents*. (Biochemical Society Symposia No. 2.) Cambridge, Engl.: at the Univ. Press; Chicago, Ill.: Univ. Chicago Press, 1948. Pp. 73. (Illustrated.) \$1.35.
- ZWEIFACH, B. W., and SHORR, EPHRAIM. (Eds.) *Factors regulating blood pressure: Transactions of the Second Conference, January 8-9, 1948, New York, N. Y.* New York: Josiah Macy, Jr. Foundation, 1948. Pp. 170. (Illustrated.) \$2.75.

NEWS

and Notes

Theodor von Kármán, director of the Guggenheim Aeronautics Laboratory at the California Institute of Technology, has been appointed an honorary professor of mechanical engineering at Columbia University in recognition of his achievements in the field of aerodynamics.

I. M. Levitt has been named associate director of electrical communications of the museum of Franklin Institute. Dr. Levitt will continue as assistant director of the Fels Planetarium of the Institute.

Kenneth S. Pitzer, professor of chemistry at the University of California, Berkeley, has been appointed to the U. S. Atomic Energy Commission as director of the Division of Research, effective January 1. While serving in this capacity, Dr. Pitzer will be on leave of absence from the University. He will direct the Commission's research program in the physical sciences and supervise the administration of the isotope production and distribution program. The position has been vacant since the resignation of James B. Fisk last August.

Torsti P. Salo, research associate in the Department of Biology at the Massachusetts Institute of Technology, has joined the staff of the University of Tennessee as associate professor. He will be concerned with the development of the field of biochemistry.

Robert J. Goodman, former research geographer at Northwestern University and geographic adviser for several governmental agencies, has been appointed to the staff of the Wayne University Geography Department.

Olof H. Selling, Swedish paleobotanist, has left for a 9-month tour of study and research in Australia and New Zealand to secure data on problems concerning the vegetation geography of this zone. He will represent Sweden at the 7th Pacific Science Congress in New Zealand, where he

will speak on fossil vegetation in Antarctica and his work in the Hawaiian Islands.

Edward A. Gall has been appointed Mary N. Emery professor of pathology and head of the Department of Pathology in the College of Medicine, University of Cincinnati, and director of that Department at Cincinnati General Hospital.

Carl F. Kayan, authority on thermodynamics, has been appointed head of the Mechanical Engineering Department, School of Engineering, Columbia University. Prof. Kayan succeeds **Theodore Baumeister**, who resigned as department head last July but continues as a faculty member.

Lewis Haas, **Nathan O. Kaplan**, **Arthur A. Rodriguez**, and **Audrey Wilson** were recently appointed to the faculty of the University of Illinois College of Medicine. Dr. Haas, assistant professor of radiology, formerly served as head of the X-ray Department, Koranyi City Hospital, Budapest, as well as associate professor of roentgenology at the Medical School of the State University in Budapest. Dr. Kaplan, named assistant professor in the Department of Biological Chemistry, is now connected with the Massachusetts General Hospital, Boston. He will assume his new duties January 1. Dr. Rodriguez, an Illinois faculty member since 1947, will be concerned with physical medicine. Dr. Wilson has rejoined the faculty as an assistant professor of radiology following a year of residence in Phoenix, Arizona.

M. J. D. White, of University College, London, has recently been appointed professor of zoology at the University of Texas. He has been engaged in conducting a series of seminars on endopolyploid conditions in cells at the University's Medical Branch, Galveston.

Alton Ochsner, William Henderson professor of surgery at Tulane University, will present the 16th E. Starr Judd Lecture on Tuesday evening, January 18, in the auditorium of the Museum of Natural History at the University of Minnesota Medical School. His subject is "The Treatment of Postphlebotic Sequelae by Vasodilatation and Other Measures."

A. V. Grosse, former director of research for the Houdry Process Corporation, was recently elected president of the Research Institute of Temple University to succeed **David N. Haysman**, who has become president of the Houdry Process Corporation. The Institute plans to devote primary effort to fundamental research in chemistry and physics under the sponsorship of industry, governmental and other interested agencies.

Robert H. K. Foster was named professor of pharmacology and director of the Department at St. Louis University School of Medicine during July of this year, replacing **John Auer**, who died April 30, 1948.

Perry Daniel Strausbaugh, head of the Department of Biology, West Virginia University, retired at the end of August. Dr. and Mrs. Strausbaugh are now residing at 6 South Lawson Boulevard, Orlando, Florida.

Keith J. Perkins has resigned as director of Child Study in the Akron, Ohio, Public Schools to accept an appointment as scientist (R) in the Commissioned Officer Corps, U. S. Public Health Service. Dr. Perkins has been assigned to duty with the Community Services Branch, Division of Mental Hygiene, as chief clinical psychologist and acting director, Phoenix Mental Health Center, Phoenix, Arizona, a PHS field-study project opened recently.

Visitors to U. S.

G. W. Leeper and **J. S. Rogers**, both of the University of Melbourne, have recently arrived in this country. Dr. Leeper, who is an associate professor of agricultural chemistry in the School of Agriculture, will spend the next few months in study of the latest developments in the treatment of soil. Mr. Rogers, of the Department of Physics at the Mildura Branch, will return to Australia in February.

D. R. Masson has arrived in Washington, D. C., to take over his duties as head of the South African Scientific Liaison Office, succeeding **E. P. Phillips**, who will return to South Africa in January. Mr. Masson's special interests lie in the field of chemical engineering.

H. W. Wollenweber, known to many U. S. scientists for his work on diseases and the taxonomy of fungi at the Biologische Reichsanstalt, Berlin-Dahlem, Germany, has arrived for an indefinite stay in this country. He is now visiting his daughter at 802 Philadelphia Avenue, Silver Spring, Maryland.

Grants and Awards

Allan P. Colburn, assistant to the president and adviser on research at the University of Delaware, was recently awarded the first Professional Progress Award in Chemical Engineering at the annual session of the American Institute of Chemical Engineers. Established by the Celanese Corporation of America, the award, carrying a \$1,000 stipend, is to be conferred annually on a person in the chemical engineering field who has not yet reached his 45th birthday and will be granted for "a theoretical discovery or development of a new principle in the field of chemical engineering; a development of a new process or product; an invention or development of new equipment; or distinguished services rendered in the field or profession of chemical engineering." Prior to the appointment to his present position, Dr. Colburn had served as professor of chemical engineering at Delaware for 9 years.

William Frederick Durand, professor emeritus of mechanical engineering at Stanford University, has been named as the first recipient of the Wright Brothers Memorial Trophy. He was cited for significant public service of enduring value to aviation in the United States. Dr. Durand left retirement during the war to head the Government's research and development program on jet-propelled aircraft.

The Council of the Royal Society of New South Wales awarded the Medal of the Society to D. W. L. Waterhouse, of the University of Sydney. The award was made in part in recognition of his services to the Society and his contributions to the field of agricultural science, particularly in regard to research on cereals.

Basil M. Bensin, agronomist with the Agricultural Experiment Station,

University of Alaska, was the recent recipient of one of the Fairbanks, Alaska, *Jessen's Weekly* First Annual Awards for Distinguished Service to Alaska. Dr. Bensin was cited for his work in building a scientific and practical agricultural economy in northern Alaska.

The second Francis Amory prize of the American Academy of Arts and Sciences, a septennial award of \$21,000 for outstanding work in the alleviation or cure of urological disorders, first made in 1940, will be equally divided among the following: Charles B. Huggins, of the University of Chicago; S. A. Waksman, of the New Jersey State Agricultural Experiment Station; G. A. Papanicolaou, of Cornell Medical College; A. B. Gutman, of Presbyterian Hospital, New York City; W. J. Koff, of Holland; and G. F. Marian, of Scotland.

The Council of the Royal Society has announced the award of two Royal Medals for the current year to Harold Jeffreys, for his distinguished work in geophysics and important contributions to the astronomy of the solar system, and to James Gray, for distinguished researches in cytology, ciliary movement, and particularly his anatomical and experimental studies of animal posture and locomotion. Other awards announced at the same time are: the Copley Medal, to A. V. Hill, for work on myothermal problems and biophysical phenomena in nerve and other tissues; the Rumford Medal, to F. E. Simon, for contributions to the attainment of low temperatures and the study of the properties of substances at temperatures near absolute zero; the Davy Medal, to E. L. Hirst, for work in the determination of the structure of sugars, starches, plant gums, and especially of vitamin C; the Darwin Medal, to R. A. Fisher, for contributions to the theory of natural selection, the concept of its gene complex, and the evolution of dominance; and the Hughes Medal, to Sir Robert Watson-Watt, for work in atmospheric physics and in the development of radar.

Phil S. Shurrager, head of the Department of Psychology, Illinois Institute of Technology, has received a \$6,000 grant from the U. S. Public

Health Service to continue research on learning in the central nervous system. Assisted by his wife, Harriett C. Shurrager, also of the Illinois Tech psychology staff, Dr. Shurrager will make further investigations of the nature of learning in a single cell, relating this smallest element to total learned behavior.

Fellowships

Applications for the 1949 Westinghouse fellowship in power systems engineering at the Illinois Institute of Technology are now being accepted. An award of \$1,500 and free tuition for three semesters of intensive training leading to a Master of Science degree in electrical engineering will be made to the successful applicant. The term of the fellowship begins September 13, 1949. Candidates must have a bachelor's degree in electrical engineering from an accredited engineering college. The award will be based on personal qualifications, interest, and scholarship. Further information and application blanks may be obtained from Dean W. A. Lewis, Graduate School, Illinois Institute of Technology, Technology Center, Chicago 16.

The Department of Chemistry, Illinois Institute of Technology, has announced the availability of graduate teaching and research assistantships for the February 1949 semester. Half-time assistants, with a teaching load of 12 hours a week, will receive \$1,314, while third-time assistants, with a teaching load of 8 hours, will receive \$876. Research assistants will be required to devote 21 hours to their assigned problem and the remainder of their time to graduate work. Applicants should write to Martin Kilpatrick, Head, Department of Chemistry, Illinois Institute of Technology, Chicago 16.

The University of Illinois Graduate College has announced the availability of 10 research fellowships to be awarded for one year in the fields of medicine, dentistry, and pharmacy. Medical and dental graduates appointed will receive a stipend of \$1,800 and pharmacy graduates, \$1,200. Registration in the Graduate College for credit toward M.S. or Ph.D. degrees is required. Appointees are exempt from tuition fees. Appointments will

be announced March 1, 1949, for the fellowship year beginning July 1 or September 1, 1949. Further information and application blanks may be obtained from the Secretary of the Graduate Committee, 1853 West Polk Street, Chicago 12.

Colleges and Universities

Establishment of marine biological laboratories in connection with two U. S. universities has recently been announced. One, to be operated jointly by the University of Hawaii and the University of California, is the Hawaii Marine Laboratory on Coconut Island, in Kaneohe Bay just off the northeast shore of Oahu, the facilities of which were recently leased by the former University from the Moku-O-Loe Corporation. A gift from Edwin W. Pauley, a regent of the University of California, and from one of the co-owners of Coconut Island will be used to recondition the buildings and provide additional facilities. The other is the re-establishment of the Narragansett Marine Biological Laboratory, at Fort Kearney, Saunderstown, Rhode Island, by the Rhode Island State College, which has been recently reopened under the directorship of Charles J. Fish, who held the same post before it was closed in 1942. The Laboratory will benefit from close association with the Woods Hole Oceanographic Institute, which has agreed to lend equipment, to open its facilities to graduate students at Rhode Island, and to furnish teaching personnel for specific lectures.

Construction of a Geophysical Institute at the University of Alaska will begin early in 1949, according to present plans. The U. S. Government will provide funds for the structures, and the University will maintain the structures and, in coordination with the president of the National Academy of Sciences, provide scientific direction and the basic staff. The unit of the University assigned to this work will be called the Geophysical Observatory. While specialized projects in arctic research had been in progress since 1929, the more integrated program, upon which the new work will be based, was begun in 1941,

under a joint arrangement with the Carnegie Institution of Washington. Under this program special studies were devoted to the ionosphere, long-distance radio-wave propagation, measurement of zenith auroral intensity, the earth's magnetic field, and seismology. During the war, through the Office of Scientific Research and Development, this program was broadened still further. Following the war, the administration of the University decided to offer the U. S. Government a site on the campus for erection of a permanent laboratory and to create a unit within the University to be devoted to geophysical research. Located at 65° N latitude and 148° W longitude, the University will provide favorable conditions for research of this kind in that it is nearly in the center of maximum auroral activity and in a region of great magnetic and atmospheric disturbances, its temperatures range from 90° to -70° F, and its climate is semiarid with clear weather predominating throughout the year.

Research contracts are now in force with several government agencies and private institutions, and proposals now under consideration may bring the annual budget to nearly \$500,000 within the year.

A plan is being inaugurated for exchange of graduate students and staff members with those in other institutions of higher learning.

The science building and equipment of Black Mountain College, North Carolina, have been totally destroyed by fire. Any donations of physics or chemistry equipment or supplies would be extremely welcome.

Meetings and Elections

The American Statistical Association will hold its annual meeting December 27-29 in Cleveland, Ohio. One of the many problems up for discussion is weaknesses in sampling methods. One program will be devoted to a paper on "Why the Election Polls Were Wrong," by Philip Hauser, of the University of Chicago, and Morris H. Hansen, statistical assistant to the director, U. S. Bureau of the Census. Rensis Likert, director of the Survey Research Center, University of Michigan, Frederick F.

Stephan, director of the Social Science Research Council's Study of Sampling, and a representative of the Gallup Poll will participate in the discussion of the topic. The statistics of the Kinsey Report will be discussed by W. Allen Wallis, of the University of Chicago, and Lowell J. Reed, of Johns Hopkins University. Other discussions of special interest will be "Basic Features of a National System of Statistical Intelligence," "Statistical Problems of Medical Diagnosis," "Union Records as Statistical Sources," "Agricultural Statistics Needed by Farmers," and "Statistical Aids to Management." Several of the sessions will be held jointly with the American Economic Association, the American Marketing Association, and other organizations meeting in Cleveland at the same time.

The Division of High-Polymer Physics of the American Physical Society will meet at Columbia University, New York City, January 27-29. More than 30 papers on the physics of natural and synthetic rubbers and plastic and filamentous materials will comprise the program.

The Crystallographic Society of America will hold its fourth annual spring meeting at the University of Michigan, Ann Arbor, April 7-9. Closing date for titles of papers for presentation is January 15 and for abstracts, March 1. These should be sent to Howard T. Evans, Jr., Laboratory for Insulation Research, M.I.T., Cambridge 39, Massachusetts. At least one session will be devoted to a symposium on some special topic of general crystallographic interest. Reservations for rooms and meals during the meeting may be made with the Michigan Union.

The 59,000 members of the American Chemical Society have chosen Ernest H. Volwiler as president-elect. Dr. Volwiler, who will head the Society in 1950, is executive vice-president of Abbott Laboratories, North Chicago, Illinois, and a leader in the field of medicinal chemistry. He has for many years been active in the affairs of both the Chicago Section and the ACS itself. The Society's president during 1949 will be Linus Pauling, chairman of

the Division of Chemistry and Chemical Engineering, California Institute of Technology, who succeeds Charles Allen Thomas, executive vice-president of the Monsanto Chemical Company, St. Louis.

Two new members of the Board of Directors also were chosen in the recent national ballot. They are Ralph W. Bost, head of the Department of Chemistry, University of North Carolina, representing the Fourth District, and Henry Eyring, dean of the Graduate School and professor of chemistry, University of Utah, representing the Sixth District.

Deaths

Edward R. Stitt, Rear Adm. (USN, ret.), 81, author and former Navy surgeon general, died November 13 at the Naval Medical Center, Bethesda, Maryland. At one time Adm. Stitt had served also as professor of tropical medicine at George Washington and Georgetown Universities and as associate professor of medical zoology at the University of the Philippines. In 1941 he became consultant on tropical medicine to the Secretary of War. He was awarded the Richard Pearson Strong Medal in 1945 for outstanding service in the field of tropical medicine.

John D. Lyttle, 58, nationally known pediatrician, died November 26 in the Hospital of the Good Samaritan, Los Angeles, California. Formerly associated with many New York hospitals, Dr. Lyttle had more recently served as medical director of the Children's Hospital, Los Angeles, and as head of the Pediatrics Department, University of Southern California Medical School.

Birdsey Renshaw, 37, associate professor of physiology at the University of Oregon Medical School, died of poliomyelitis November 23 in Portland.

George H. Ramsey, 57, epidemiologist and former Health Commissioner of Westchester County, New York, died in a sanatorium at Saranac Lake November 30. Responsible for a number of advances in the control of communicable diseases while with the N. Y. State Department of Health from 1933 to 1938, Dr. Ramsey at one

time served as president of the American Epidemiology Society and as chairman of the Epidemiology Section, American Public Health Association.

On the 45th anniversary of the first human flight, made by Wilbur and Orville Wright on December 17, 1903, at Kitty Hawk, North Carolina, the historic airplane was formally given into the custody of the Smithsonian Institution, in accordance with the wishes of the late Orville Wright. After the ceremonies were opened by Alexander Wetmore, secretary of the Smithsonian Institution, a message from President Truman was read by Col. Robert B. Landry, Air Force aide to the President, and Sir Oliver Franks, the British Ambassador, spoke on "Britain and the Wright Brothers." The plane has been displayed on a loan basis in the Science Museum, South Kensington, London, since 1928, and was only recently brought to the United States. It will eventually be transferred to the National Air Museum.

The new clipper *America*, just delivered by Boeing to Pan American Airways and shown on this week's cover together with a photo of the Wright brothers' original 745-pound biplane, serves to point up the four and a half decades of progress in the field of aviation. The two-story, 75-passenger, 340-m.p.h., 14,000-horsepower liner with a range of 4,200 miles and a payload of 142,500 pounds is here compared with the 1-passenger, single-engine, 12-horsepower machine which had a top range of 24½ miles and cost less than \$1,000—a sum which included the Wright brothers' train fare to North Carolina!

Publication of Cancer Research, the official organ of the American Association for Cancer Research, has been transferred from the Ann Arbor Press to the University of Chicago Press. The monthly journal will continue to publish results of original cancer research and general reviews. Paul E. Steiner, professor of pathology at the University of Chicago, will be the new editor. He will be assisted by W. U. Gardner, of Yale University, Balduin Lucke, of the University of Pennsylvania, Harold Rusch, of the University of Wisconsin,

and an advisory staff of 26. Co-sponsors of the journal with the Association are the Anna Fuller Fund, cancer research division of the Donner Foundation, Inc., the Jane Coffin Childs Memorial Fund for Medical Research, and the Elsa U. Pardee Foundation.

The National Registry of Rare Chemicals, 35 West 33rd Street, Chicago 16, Illinois, has submitted the following list of wanted chemicals: homomyristicylamine, homopiperonylamine, 1,2,3-triazine, 1,2,4-triazine, 1,2,5-triazine, pentazine, 1,2,4,5-tetrazine, spinulosin, fumigatin, glucoheptose, glucooctose, glucononose, stachyose, phosphorous oxychloride difluoride, 3-nitro-1-butanol, mesobilirubinogen, stannous fluoride, fluorogermane, germanium dichloride, and l-camphoric acid.

Queen Maud Land in Antarctica is the destination of a combined British-Norwegian-Swedish expedition leaving at the end of next year for a three-year study of the geology, climate, and meteorology of the region. The expedition was originally planned by Hans W. Ahlman, of Stockholm, and will be directed by H. U. Sverdrup, director of the Norwegian Arctic Research Institute. They will leave aboard the first ship of the expedition, scheduled to arrive in Antarctica by the end of 1949, and return in March 1950, leaving a dozen British, Norwegian, and Swedish scientists to conduct studies until 1952. The equipment includes a helicopter, for mapping purposes and for possible use should heavy ice prevent ships from reaching the coastline, and two "Weasels," track-propelled vehicles designed during the war for cross-country transportation.

The Franklin Institute, Philadelphia, has arranged several special programs for the Christmas season. One of these, "Star of Bethlehem," will be presented through January 2 by the Fels Planetarium of the Institute. In the museum two new exhibits are now on display, one on atomic energy and the other of prints from the 2nd International Photography-in-Science Salon, an annual competition sponsored by the *Scientific Monthly* and the Smithsonian Institution. The

Little Theatre of the museum is now showing "The ABC of Internal Combustion," a film produced by General Motors Corporation, and "Naval Photography in Science," by the Navy Department. All of the programs will be presented each day with the exception of Monday.

A seminar on the Virus Diseases of Man and Animals is being sponsored by the Graduate School of the Department of Agriculture during the forthcoming spring semester, beginning the week of February 7. In this seminar, which will be under the leadership of Karl Habel, chief of the Neurotropic Virus Unit of the National Institutes of Health, attention will be given to the more recent advances in animal and plant virus studies and techniques, including fundamental considerations and practical application in the research and clinical fields. Dr. Habel will be assisted by a number of specialists in the field. Further information may be obtained from the Graduate School, U. S. Department of Agriculture, Washington 25, D. C.

Publication of a new semiannual popular journal called *Frontiers of Plant Science* has been announced by the Connecticut Agricultural Experiment Station. Intended primarily to acquaint farmers and gardeners of Connecticut with the latest research developments of the Station, the 8-page journal will consist of short, popular, illustrated articles by staff members. The journal, to be issued each spring and fall, will be edited by Amanda Quackenbush, Experiment Station editor.

The lead article in the first issue describes the Station's 30 years of work with hybrid corn, tracing the pioneer research of Donald F. Jones and discussing the Station's present-day work with field and sweet corn. Other articles include: "Should We Stop Cultivating?" by C. L. W. Swanson; "New Tools for Lawn Insect Control," by John C. Schread; and "Blame for Baffling Tobacco Disease Laid to Nematodes," by P. J. Anderson. Any resident of Connecticut may receive copies of *Frontiers of Plant Science* upon application to the Connecticut Agricultural Experiment

Station, Box 1106, New Haven 4, Connecticut.

An advice service to industry on research uses of new radioactive materials produced at Britain's Atomic Energy Research Establishment at Harwell was established by Director John D. Cokeroff with the bringing into operation of the second atomic pile there. A. W. Haslett, editor of *Science Today*, writes: "It is expected that the new pile, with a rated power output of 6,000 kilowatts, will produce all the radioactive materials needed by Britain's research workers whether for medical or industrial purposes, and it is hoped to extend supplies also to members of the British Commonwealth and other overseas countries. The most important progress in the research use of such materials has so far been for medical purposes. The new advice service is to ensure that lack of knowledge shall be no bar to their effective use." The purposes of the service are: (1) to inform individual industrial firms of the type of uses to which the radioactive materials can be put; (2) to explain the technical methods of measurement which are necessary and the difficulties which may arise in practice; (3) to dispatch research teams to firms to assist in carrying out whatever experiments may be necessary. "The object of Britain's Harwell arrangements," Mr. Haslett concludes, "is to save time by bringing the [tracer] method to industry."

The U. S. Department of Agriculture has reported that experiments with certain low-level radioactive materials conducted during the 1948 crop year in 14 states and with 18 crops have thus far not shown any beneficial effect upon either crop growth or quality. The comprehensive tests, undertaken in March of this year at the request of, and with funds provided by, the AEC, were the first to be made under a proposed two-year study to be conducted by the USDA and cooperating agricultural experiment stations.

A special list of recent scientific and technical publications of British government agencies, just compiled by the Office of Technical Services, Department of Commerce, is now available to the public without charge. The Office states that although the data are not always directly applicable to

American manufacture and research they are often of value because of the unique approach taken abroad to certain technical problems which also confront American industry. Copies may be obtained through the Reference Service of OTS, Washington 25, D. C.

Make Plans for—

Association of American Geographers, December 27-30, Union Building, University of Wisconsin Madison.

American Anthropological Association, American Folklore Society and Society for Applied Anthropology, December 28-30, Royal Ontario Museum of Archaeology and University of Toronto, Toronto, Canada.

American Astronomical Society 80th meeting, December 28-31, Yale University, New Haven, Connecticut.

Mathematical societies, Ohio State University, Columbus: American Mathematical Society, December 28-30; National Council of Teachers of Mathematics, December 29-30; Mathematical Association of America, December 31.

Recently Received:

Dow Diamond. Published monthly by the Dow Chemical Company, Midland, Michigan, and distributed without charge.

The Natural History Bulletin. Issued monthly (October-June) by the Natural History Museum, Balboa Park, San Diego, California.

Industrial Bulletin of Arthur D. Little, Inc., November 1948.

Methods used to control pollination of pines in the Sierra Nevada of California, by W. C. Cumming and F. I. Righter. (Circ. No. 792, U. S. Department of Agriculture.) Washington, D. C.: U. S. Government Printing Office, 1948. \$10.

Technical Data Digest. Issued semi-monthly by the Central Air Documents Office (Navy—Air Force). Inquiries may be addressed to Commanding General, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio, Attn: Air Documents Division, MCIDXS5. **Airborne Instruments Laboratory, Inc.**, 160 Old Country Road, Mineola, New York. Illustrated booklet describing history, staff, work, and policies of the Laboratory.